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Filling the Ladle

Volume 59
No. 2

MECHANICAL ENGINEERING

February
1937

GEORGE A. STETSON, *Editor*

Professional Recognition

ENGINEERS should read with care, with particular attention to the "Summary of Recommendations," the report of the Committee on Professional Recognition of the Engineers' Council for Professional Development which will be found on pages 135 and 136 of this issue. As explained in the opening paragraph accompanying the report, the Council, at its meeting of October 6, 1936, deferred official action on the recommendations until further consideration might be given them.

In view of the importance of the recommendations made by the committee, and their implications, the report is published so that the opinions of engineers may be heard before official action is taken by the E.C.P.D.

Increasing Our Usefulness

LAST month tribute was paid in these columns to Leon Cammen who, for 25 years, provided abstracts of engineering papers published in other periodicals. To carry on Mr. Cammen's work in exactly the manner used by him would require a person whose talents were the same as his. Hence it has been necessary to approach the task from a different angle with the hope of rendering much the same service. The initial effort in this direction is to be found in a newly established section "Briefing the Record," pages 112–119 of this issue.

The critical attention of all readers is invited to this section. The objective aimed at is to provide our own digest of current literature bearing on the work and interests of engineers. To younger men particularly it is hoped that these brief comments and abstracts may serve as a means of calling attention to matters that might otherwise escape their attention and the reading of which may broaden their interest in many fields. While the material formerly presented by Mr. Cammen dealt almost exclusively with technology, it will be noted that a wider field is covered in the present abstracts. It is planned to preserve some measure of balance in this broader picture of the field of engineering by attention, perhaps not completely every month, to economic conditions, science, engineering education, biography, and history, professional relationships to society and in the law, and borderline fields of engineering, as well as mechanical technology. Nor will engineering periodicals alone serve as sources of the material presented, as this month's abstracts prove.

In inaugurating this reorganized service, Mechanical Engineering strives to increase and broaden its usefulness. Criticism and comment are invited as a basis for constructive development.

Engineering-School Enrollments

FROM time to time statements are made or appear in the press to the effect that too many young men are preparing for the engineering profession. Of late years particularly, with unemployment in the profession a matter of vital concern to individuals as well as to society itself, a spirit of defeatism, and possibly also of fear of a keen competition for jobs held by older men who feel themselves none too securely placed, has prevailed. More optimistic views are likewise expressed, principally by educators, who, though they may possess a reasonable amount of proprietary interest in enrollments in their institutions, are constantly impressed by the demands of industry for their product, even during the darker days of depressions and by the placement records of graduates.

Certain it is that statistics continue to indicate the value to practicing engineers of the quality and extent of their collegiate training. Furthermore, it is increasingly evident that a sound education in engineering is a splendid training for a great variety of positions that, under a strict interpretation of the term, cannot be classed as engineering in the professional sense.

Interest attaches, therefore, to statistics of enrollment in engineering courses for 1936–1937, which are available in tabular form in the December, 1936, issue of the *Journal of Engineering Education*, published by the Society for the Promotion of Engineering Education.

These statistics are the result of replies from 119 institutions in the United States and Canada to inquiries addressed to 150 such institutions. They show total registrations of 67,569 (in 118 institutions) in 1936–1937 as compared with 66,541 (in 124 institutions) in 1935–1936. Figures of total registrations for the present academic year in courses of interest to mechanical engineers are as follows: Aeronautical 1355, industrial 1572, and mechanical 13,146. Of all engineering courses, mechanical engineering shows the largest registration. Disregarding "unclassified," the next largest group is electrical engineering with 10,678 registrants. These figures relate to undergraduates in schools in the United States. The total registration in four Canadian schools is 1744, but here the greatest number is in civil engineering, 359; mechanical, 230.

A supplementary table gives undergraduate enrollment

by institutions. Among these Purdue has the largest number, 3030, and Armour Institute is second with 2082, of which 1244 are evening students. The A. and M. College of Texas has a registration of 1993 and other large enrollments in institutions with no evening courses are University of Illinois 1889, Massachusetts Institute of Technology 1792, and Ohio State 1737.

Enrollments of students taking graduate work are recorded in a third table. The total enrollments for master's and doctor's degrees in colleges in the United States are 2099 and 362, respectively. The Massachusetts Institute of Technology heads the list with 312 registered for work for the master's degree and 94 for the doctor's degree. In the Polytechnic Institute of Brooklyn 230 are enrolled for work for the master's degree. Columbia, with a total undergraduate enrollment of 413 has 96 enrolled for the master's and 57 for the doctor's degree.

From these figures it is indicated that there is no falling off in undergraduate enrollments, that mechanical-engineering courses are largely selected, and that post-graduate education is showing a healthy development.

Every Member May Be Proud

FOR many years, as some readers may recall, it was an almost traditional procedure to publish reports of the A.S.M.E. Special Research Committee on the Thermal Properties of Steam in the February issue of MECHANICAL ENGINEERING. With the work of this committee and that of groups of researchers in the subject in this country and in other lands properly correlated through the International Steam Tables Conferences, a reasonably accurate working knowledge of the thermal properties of steam in regions that a decade ago were covered only by extrapolation has been acquired.

Yearly meetings of the committee have ceased to provide the wealth of technical material that made them at one time so eagerly attended by an enthusiastic group of keenly intelligent researchers, discussers, and critics, and the reports themselves have disappeared as a feature of our February issue. But this month a "review" of the recently published Keenan-Keyes tables, prepared by R. C. H. Heck, whose name has long been connected with this important research and who made notable contributions to formulations of these thermal properties, temporarily revives the "February tradition."

Professor Heck's "review" takes the form of a comparison of the Keenan-Keyes values and formulation with those of the Keenan tables, published by The American Society of Mechanical Engineers in 1930, the Goodenough, and the Heck equations of state. Thus there is provided for students of this subject a series of charts that will be most interesting to them.

The history of the origin, work, and progress of the A.S.M.E. Special Research Committee on the Thermal Properties of Steam has been told many times in these pages and elsewhere. The attention of lay readers was called to it as recently as the January issue of *The Atlantic* in an article entitled "Full Steam Ahead," although the author, George W. Gray, unfortunately failed to mention The American Society of Mechanical Engineers in connection with his brief comment. Yet without the Society as the organizing and correlating agency it may be doubted if the work would ever have been undertaken on the scale of thoroughness and authority that distinguished it throughout its history. For years to come this service of the Society will remain as an extraordinary illustration of an engineering society at its best, fulfilling a function that appertains to such organizations and that may be considered as a justification of its existence.

It would be difficult to estimate with accuracy the number of members of the Society that are directly benefited by this work. As in all examples of such service, the Society here bears precious fruit. Pride in the accomplishment may be shared by all who, through their membership, have maintained an organization through which such results are achieved. Here is one of those outstanding cases in which the individual member can congratulate himself on having been associated with an important service to the profession. The prestige of the Society has grown enormously because of this service, and in that prestige every member shares an intangible benefit, let us say, of membership—one of those that makes a society truly great. More of them must and will follow if The American Society of Mechanical Engineers is to retain the position of leadership in the profession that it has made for itself.

A.E.C. Hits Its Stride

IT IS unfortunate that neither time nor space permits publication this month of the report on the activities of the American Engineering Council presented by F. M. Feiker, executive secretary, at the 1937 annual assembly. To any one who heard the report and who has been following the history of the Council, it will be evident that the A.E.C., under Mr. Feiker's administration, has reached a maturity of effective national service that deserves the commendation and enthusiastic support of all engineers and engineering societies.

The Council is exercising a leadership in coordinating the influences of engineers all over the country in an effort to make effective for the general public welfare the services of individuals and engineering societies in national affairs. Furthermore, it concerns itself with proposed legislation that is likely to affect engineers or that, to be wisely enacted, needs engineering advice and opinion. Through it, national, state, and local societies gain a sense of a common purpose and find stimulus for their individual attention to public questions. As its development is tending at present the Council will serve as a means by which experiences in engineering projects of a public nature, such, for example, as those dealing with water resources, land conservation and use, and rural electrification, may be transmitted to sections of the country where similar projects are contemplated, and for reflecting local opinion on federal plans and projects to Washington.

The STEAM TURBINE *in the* UNITED STATES

II Early Allis-Chalmers Steam Turbines

By A. G. CHRISTIE

THE JOHNS HOPKINS UNIVERSITY, BALTIMORE, MD.

THE ALLIS-CHALMERS CO. was formed in 1901 as a consolidation of the E. P. Allis Co., of Milwaukee, Wis.; Fraser and Chalmers Co., Chicago, Ill.; the Gates Iron Works, Chicago, Ill.; and The Dickson Iron Works, Scranton, Pa. Fraser and Chalmers Co. built boilers and mining machinery, the Gates Iron Works a line of crushing machinery, and the Dickson Iron Works steam engines of several types and mill equipment. The E. P. Allis Co. was one of the leading builders of steam engines, pumps, and condensers. Under the direction of the chief engineer, the late Edwin B. Reynolds, the E. P. Allis Co. had developed the Reynolds-Corliss engine to a high degree of perfection and had built many of the largest units in use in the central stations of American and foreign public utilities. An outstanding feature of the machinery building at the St. Louis Exhibition of 1904 was the large horizontal-vertical Reynolds-Corliss engine. Allis pumping engines had also established records of performance in many of the municipal pumping plants of the country.

While the author knew from hearsay of many of the incidents connected with the early turbine developments of Allis-Chalmers Co. previous to 1905, he is indebted for correct information to Max Patitz, consulting engineer, Allis-Chalmers Co.; to Max Rotter, vice-president of Busch-Sulzer Bros. Diesel Engine Co. of St. Louis and former manager of the steam-turbine department of Allis-Chalmers Co.; and to Geo. A. Orrok, formerly mechanical engineer of the New York Edison Co., all of whom have contributed sections to this paper.

About 1899, Patitz called the attention of Edwin Reynolds to the steam turbine which was then undergoing development in Europe. Patitz expressed the belief that the steam turbine might become a serious competitor of the reciprocating steam engine. Reynolds was interested in this turbine development but nothing was done until after the formation of the Allis-Chalmers Co. The board of directors of that company early in 1902 voted the sum of $10,000 for investigations of the steam turbine.

Irving H. Reynolds, a nephew of Edwin Reynolds, proceeded to Europe to investigate steam turbines early in 1902. Later in the same year Max Rotter also went to Europe for a similar purpose as well as to carry on other investigations. Their reports on steam-turbine development induced the company to consider the construction of steam turbines.

THE BACKSTROM RADIAL TURBINE

Chas. Backstrom, an inventor of a steam turbine bearing his name, was engaged in 1902 by Allis-Chalmers Co. to design a machine of his type. Like many other turbine inventors of that period, Backstrom did not seem to know much about the expansion of steam and its action in nozzles and blades. With the assistance of Patitz a radial turbine as shown in Figs. 1, 2, and 3 was designed. This consisted of one wheel $49^5/_8$ in. in diameter with blades on both sides of the disk, and with steam furnished to the center through six 2-in. valves. The steam passed through the blades and from the outer circumference through a volute chamber to the exhaust opening. The wheel was designed to run condensing at 1200 rpm, but no condenser was ever provided for it. After completion, several attempts were made to run this machine but the blades fouled and were torn out every time. Backstrom then left Allis-Chalmers Co. and went to Filer and Stowell, another engine-building firm in Milwaukee. He afterward had a steam turbine of the Rateau impulse type built by Filer and Stowell, but this developed mechanical difficulties and was abandoned.

After Backstrom left Allis-Chalmers Co. Patitz continued to experiment with the radial turbine, then facetiously called in the shops "Allis' Folly." He succeeded in making it run, but without a condenser, it would develop only about 12 hp instead of 300 hp for which it was designed. Quite obviously the difficulty was due to lack of vacuum, for a radial turbine of this design and intended for condensing operation has large losses due to disk friction and internal resistances when run noncondensing.

IMPULSE TURBINES

While the Backstrom turbine was under development, Allis-Chalmers Co. entered into negotiations with the Escher-Wyss Co., Zurich, Switzerland, with a view of ultimately securing a license to build the Zoelly turbine which was being developed by the latter firm. In December, 1902, the Escher-Wyss Co. cabled that everything was ready for the test upon the results of which a decision to take out a license would be based. Patitz was sent to Europe in December, 1902, to run preliminary tests on the Zoelly turbine. If the results of these preliminary tests were satisfactory, Prof. W. Unwin of London was to be notified as he was to conduct the official tests for Allis-Chalmers Co. Upon arrival at Zurich, Patitz found that there had been some misunderstanding among the officials of Escher-Wyss Co. in regard to this test. The only completed turbine available for test was one which had blades of the Pelton type, milled out of steel bars, and tapered toward the outside diameter, as shown on pages 112 to 114 of the first German edition of Stodola's book, "Die Dampfturbinen."

Dr. Zoelly intended to discontinue this type and to construct an axial-flow impulse turbine of the Rateau type. The steam consumption of this Pelton-type turbine was 40.5 lb per kwhr with a steam pressure of 156 lb per sq in. gage, dry steam, and

Contributed by the Division on Engineering History and the Power Division and presented at the Annual Meeting, New York, N. Y., Nov. 30 to Dec. 4, 1936, of The American Society of Mechanical Engineers.

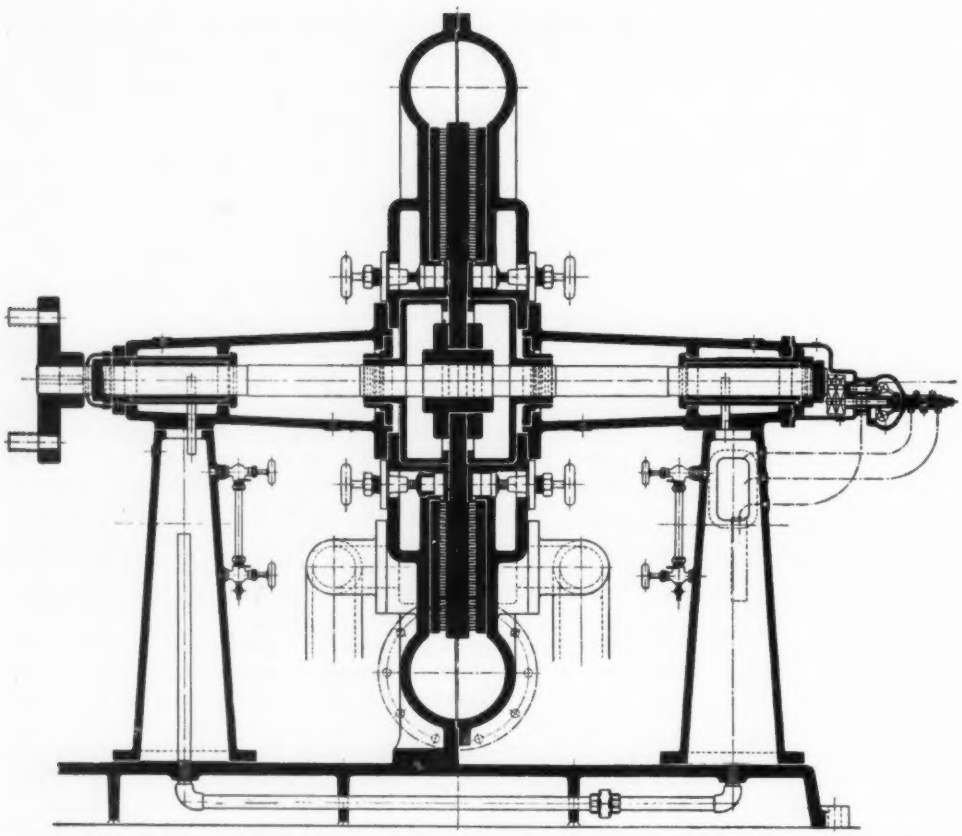

FIG. 1 SECTION OF BACKSTROM RADIAL-FLOW TURBINE SHOWING NOZZLES AND BLADING

designed by its engineer, Lindmark. Steam entered the hollow wheels at the center and was discharged through holes on the rim at high velocity and this velocity was to be converted again into pressure in stationary diffusers. This scheme works well with water but not with steam. The Lindmark turbine is described on pages 295–299 of Lowenstein's translation of the second edition of Stodola's "Die Dampfturbinen," issued in 1905. The Lindmark idea was not acceptable to Patitz and, as far as known to the author, this turbine has never been a commercial success. In the meantime, the DeLaval Co. in the United States had opened negotiations with Allis-Chalmers Co. and Patitz was recalled to New York to report on the Lindmark turbine. No further action was taken by Allis-Chalmers after Patitz's report was received.

At that time, 1903, nothing could be done to secure rights to build the Parsons turbine and certain Parsons patents in America had been secured by the Westinghouse Machine Co. Patitz was authorized by Allis-Chalmers to proceed with the development of a steam turbine along such lines as he conceived to be best. Very little was known in those days regarding either the theory or the practical operation of steam turbines. The optimum

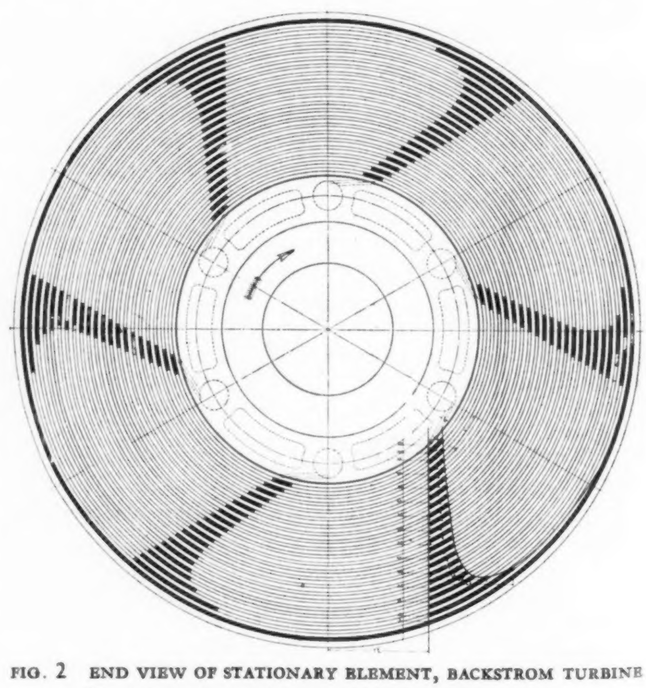

FIG. 2 END VIEW OF STATIONARY ELEMENT, BACKSTROM TURBINE
(Shaded portions only form blade passages in stator.)

a 26-in. vacuum. Such performance was so unsatisfactory that there was no need to call on Professor Unwin for an official test.

Allis-Chalmers cabled Patitz to see if other concerns had steam turbines sufficiently well developed that their construction in America might be undertaken. At the same time Patitz was to look over gas engines built for use with blast-furnace gas, in company with Schulze-Pillot, at present professor at the Technical Hochschule at Danzig. They went to the M.A.N. works at Nurnberg, Germany.

M.A.N. had built for experimental purposes a small impulse wheel 8 in. in diameter. On the strength of the tests on this wheel, a multistage impulse steam turbine with wheels about 25 in. in diameter was being built. M.A.N. had at that time no developed steam turbine to offer to Allis-Chalmers Co.

Hans Holzwarth was in charge of the steam-turbine development at M.A.N. Later Holzwarth came to the United States and worked for a while for Allis-Chalmers Co. at Milwaukee. Later he went to Hooven, Owens, and Rentschler, Hamilton, Ohio, and designed and built several sizes of impulse turbines, one of which was exhibited at the World's Fair at St. Louis in 1904. This latter turbine never operated satisfactorily during the Fair. Its generator was built by the Bullock Electric Co., Cincinnati, O., before that firm became part of Allis-Chalmers Co. In this way the Bullock Works gained early experience in the construction of turbogenerators. These Holzwarth turbines did not prove a commercial success and Holzwarth returned to Europe about 1905 where he later developed the gas turbine with which his name is associated today. Hooven, Owens, and Rentschler then abandoned turbine construction.

From Nurnberg, Patitz and Schulze-Pillot went to Stockholm, Sweden, to see whether DeLaval Co. had developed a steam turbine suitable for large power stations. This company was experimenting with reaction radial-type turbine wheels

relation of wheel speed to steam speed was an unknown quantity. Nor were Mollier or other diagrams in existence to determine heat changes. Stodola's first edition of "Die Dampfturbinen" did not appear until later in 1903. Neilson's book, "The Steam Turbine," published in 1902, was largely descriptive and dealt principally with the Parsons turbine. Patitz commenced some experiments to determine the best shape of blades and the amount of disk friction before starting actual turbine design. Shortly after these experiments were started, the need for a turbine became so urgent that the firm insisted upon an immediate design. A steam turbine was developed forthwith for 300 bhp at 3000 rpm with dry steam at 180 lb per sq in. and a 28-in. vacuum. This turbine is embodied in patent No. 971,555 for which an application was filed by Patitz on Jan. 11, 1904, and the patent was finally issued on October 4, 1910. A description of the turbine appeared in *Power*, April 28, 1911.

In developing this design, Patitz's idea was to use wheels running at a moderate circumferential speed, to let the steam issue from the nozzles at a high velocity, however, not to abstract the residual velocity in wheels of so-called velocity stages, as for instance, Curtis did, but to shape the entrance to the nozzles for the succeeding stage so as to take care of the residual velocity and then expand the steam further in the nozzles so that the velocity of the steam issuing from the nozzles to the wheel of the following stage was as high as that of the preceding stage. The velocity of steam issuing from the nozzles was kept approximately the same in all stages except the last one. The result was a large conversion of energy into work in each row of blading and consequently only a small number of stages were necessary.

The first Patitz turbine had six stages as shown in Figs. 4, 5, and 6. In order to compare the efficiency of the Patitz turbine with a regular impulse type of machine, a turbine of the latter type was designed which was to have 16 stages. As in the meantime a change of management of the Allis-Chalmers Co. took place, and it also became possible to obtain a license under the Parsons patents, the impulse turbine was abandoned for large-size turbines and this 16-stage unit was therefore only partly built.

When the six-stage unit was completed, it was tested at the Milwaukee Street Railway Co.'s power house because the Allis-Chalmers Co. had no boiler for a pressure of 180 lb per sq in. nor was a surface condenser available. At the Street Railway's power house, there were boilers available for a steam pressure of 160 lb per sq in. and also a surface condenser. The latter with 300 hp on the turbine could produce only 25.5 in. of vacuum instead of 28 in., and as a result the sixth wheel of the turbine did no work and was a hindrance rather than a help.

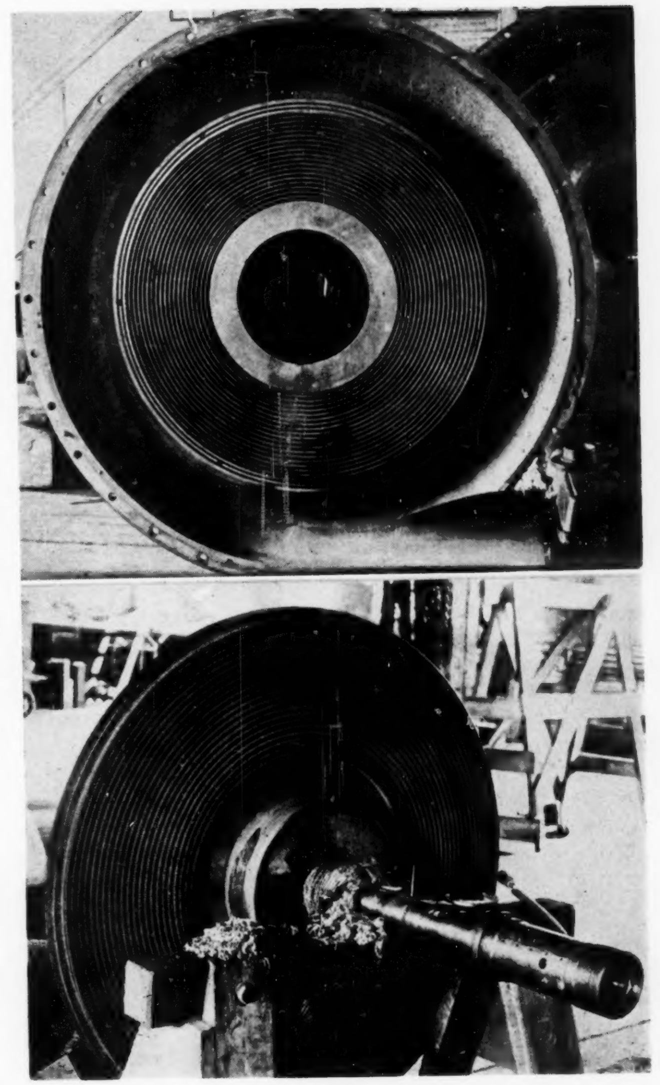

FIG. 3 ROTOR AND STATIONARY ELEMENTS OF BACKSTROM TURBINE

TABLE 1 TESTS OF PATITZ' STEAM TURBINE

	Varying load—normal speed					Varying vacuum—constant load		
Number of test	19	20	21	22	23	24	25	26
Brake horsepower	301.5	234.2	164.27	93.52	11.28	258.41	258.75	257.44
Revolutions per minute	2932.5	2964	2975	2977	2963	3076	3020	3010.5
Steam pressure at throttle lb abs	163.44	162.4	162	164.73	161.72	160.94	161.93	161.84
Moisture in steam, per cent	3.4	4.4		4.7	1.4	3.1	3.6	4.2
Vacuum in exhaust at turbine referred to 30-in. barometer, in. Hg	25.72	26.5	26.75	27.06	26.46	20.78	22.85	26.62
Barometer, in. Hg	29.42	29.42	29.41	29.4	29.38	29.35	29.31	29.31
Dry steam per bhp-hr, lb	19.58	19.63	20.27	22.29		23.88	22.43	19.63
Dry steam per hr, lb	5903.4	4597.3	3329.7	2084.6	585.7	6170.8	5803.8	5063.4

Allowing for the deficiency in steam pressure and vacuum, the turbine was about as efficient as the 5000-kw Curtis steam turbine supplied about that time by the General Electric Co. to the Fisk St. Station of the Commonwealth Edison Co., Chicago, Ill. Some of the test data on this 300-hp turbine are given in Table 1.

In the early years of steam-turbine development it was thought that the Parsons turbine was not so well adapted to smaller sizes up to 500 kw as the impulse turbine, on account of the very short Parsons blades that must necessarily be used on the high-pressure end. The steam consumption of such small early Parsons units was higher than that of impulse turbines of the same size. In 1909, W. Whiteside, then president of Allis-Chalmers Co., had Patitz design a 750-kw impulse turbine for dry steam at 150 lb per sq in. gage, 28-in. vacuum, and 3600 rpm. This turbine had eight wheels 25 in. in diameter. Its steam consumption was estimated at 19.78 lb per kwhr, which was better than the Parsons turbine of

similar size could do at that time. The construction of this experimental unit was delayed and it was not tested until November, 1914. Its actual steam consumption was 19.28 lb per kwhr.

By that time, 1914, the Parsons turbine had undergone further

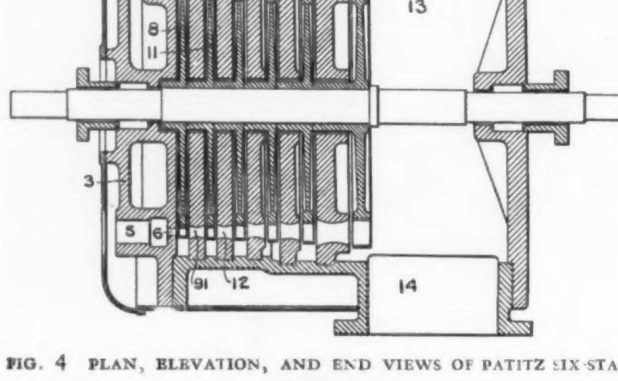

FIG. 4 PLAN, ELEVATION, AND END VIEWS OF PATITZ SIX-STAGE TURBINE

development so that better consumptions could be guaranteed than those obtained with this impulse turbine. No doubt if impulse turbines had been built continually and improved during the five years this one was under construction, much better results in steam consumption could have been obtained.

Small impulse turbines for exciters have been built during all the years from 1904 to date.

THE FIRST TURBINE SALES

Early in February, 1903, the Brooklyn Heights Railroad Co. contemplated the development of their Kent Avenue property into a modern power house of maximum size and E. W. Winter, president, secured a report under date of April 8, 1903, from Thomas E. Murray, general manager and chief engineer of the New York Edison Company which reviewed the prime-mover situation and commented on the experimental nature of the turbine.

Winter entrusted the building of the new station to Murray and the design work proceeded under Geo. A. Orrok, mechanical engineer of the New York Edison Company and assistant engineer to Murray. Proposals for engines of four types and turbines of two types (Westinghouse and General Electric) were secured, the engines being of 12,000 hp, while the turbines were about half this size, i.e., 5000 kw. Allis-Chalmers Co. offered the most attractive engine, although the Southwark Foundry and Machine Company's proposal was also an attractive one. But the turbine prices were about 60 per cent of the engine prices and both Murray and Winter were inclined to the experiment of using them in the new plant.

B. H. Warren became president of Allis-Chalmers Co. in January, 1904. Warren had previously been associated with the Westinghouse Electric and Manufacturing Company where he had had experience with the Parsons turbine. Shortly before this time, Parsons had again secured control of his patents and the Allis-Chalmers Co. considered the possibility of taking out licenses from Parsons. As will be evident from the preceding paragraphs, a thorough investigation had been made of the Rateau, Zoelly, Ljungstrom, Electra, Lindmark, Stumpf, Zahikjanz, and practically every other type of turbine developed in Europe between 1902 and 1904 before deciding upon the Parsons type of turbine. Under instructions from Warren, Robt. A. McKee was engaged by Arthur West of Allis-Chalmers Co. to start designs of Parsons turbines.

McKee was graduated from Lehigh University in 1895 and obtained the degree of M.M.E. from Cornell University in 1897. He was afterward employed on engineering work with Brooks Locomotive Works, Baldwin Locomotive Works, and Holly Manufacturing Co. In 1901 he became connected with Westinghouse Machine Co. McKee joined Allis-Chalmers Co. early in 1904, taking charge of the development and construction of steam turbines. To his efforts more than to those of any other individual is due the sound development of the early Allis-Chalmers turbines. McKee died suddenly in 1915.

While McKee was in the position to go ahead with Parsons turbine designs, patent rights had to be secured. For some reason, licenses with Parsons direct were not immediately available. Certain patent rights and licenses were secured from the Turbine Advisory Syndicate, Newcastle, England, and arrangements were made to secure design and performance data from that source. Willans & Robinson, Rugby, England, were members of this syndicate and this firm had completed designs of several sizes of turbines, embodying the features of the Sankey and Fullager patents. An arrangement was completed by which these drawings and designs were made available to Allis-Chalmers Co. for sales purposes in America.

When Warren became president of Allis-Chalmers, the engine salesman at their New York office, Mr. Larkin, was superseded by J. H. Vail who immediately pressed the claims of the tur-

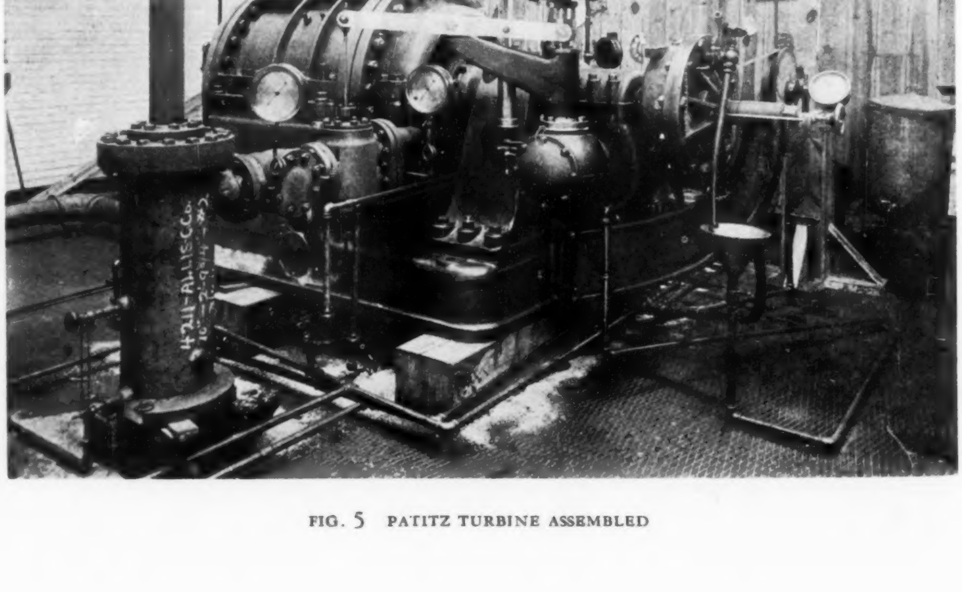

FIG. 5 PATITZ TURBINE ASSEMBLED

bine. Thos. E. Murray and N. F. Brady of the New York Edison Co. believed the time was ripe to use the cheaper form of prime mover. A. N. Brady, chairman of the board of directors of the Brooklyn Heights Railroad Co., was not willing to take the gamble, so Murray and N. F. Brady bought from Vail, sight unseen, five turbines on their personal account for later assignment. In Fig. 7 is shown a copy of the famous pencil order as given by Mr. Murray. Vail had no Allis-Chalmers drawings, and only a Willans and Robinson sketch. It was agreed that the first two turbines should be made in England at the Willans and Robinson shops. The first turbine was to be of 1500 kw capacity and was assigned to the Utica Gas and Electric Company, the final contract being dated in April, 1904.

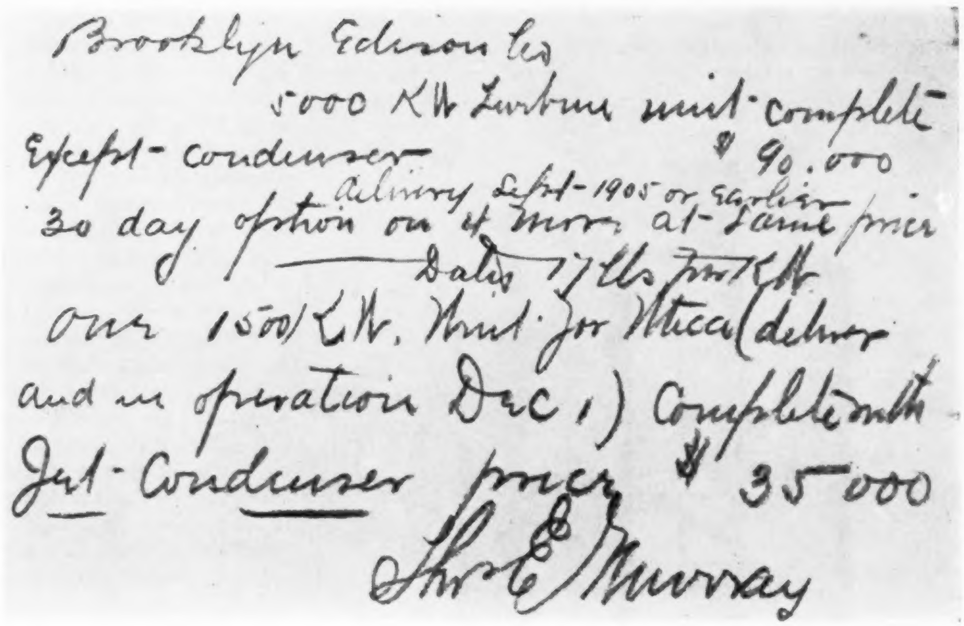
Brooklyn Edison Co
5000 KW Turbine unit complete
Except condenser $90.000
delivery Sept-1905 or earlier
30 day option on 4 more at same price
Dated
One 1500 KW. Unit for Utica (delivered
and in operation Dec 1) complete with
Jet-Condenser price $35000
Thos E Murray

FIG. 7 COPY OF THE FAMOUS PENCIL ORDER SIGNED BY THOMAS E. MURRAY

Allis-Chalmers Co. immediately took up the design of the Kent Avenue turbine and on Mar. 3, 1904, submitted contract drawings for this 5500-kw machine. The building of this machine was to have been entrusted to Willans and Robinson, but delay in the shipment of the 1500-kw Utica machine transferred the actual manufacture to the West Allis shops. The contract with the Transit Development Co. was dated April 4, 1904.

The third machine, 1500 kw, went to the North River (Rider Avenue) station of the New York Edison Co., the fourth machine to the Westchester Lighting Co., and the fifth to the Dayton Power and Light Co. Later, the contract was extended to include a sixth machine of 1500 kw which went to the Memphis Power & Light Company.

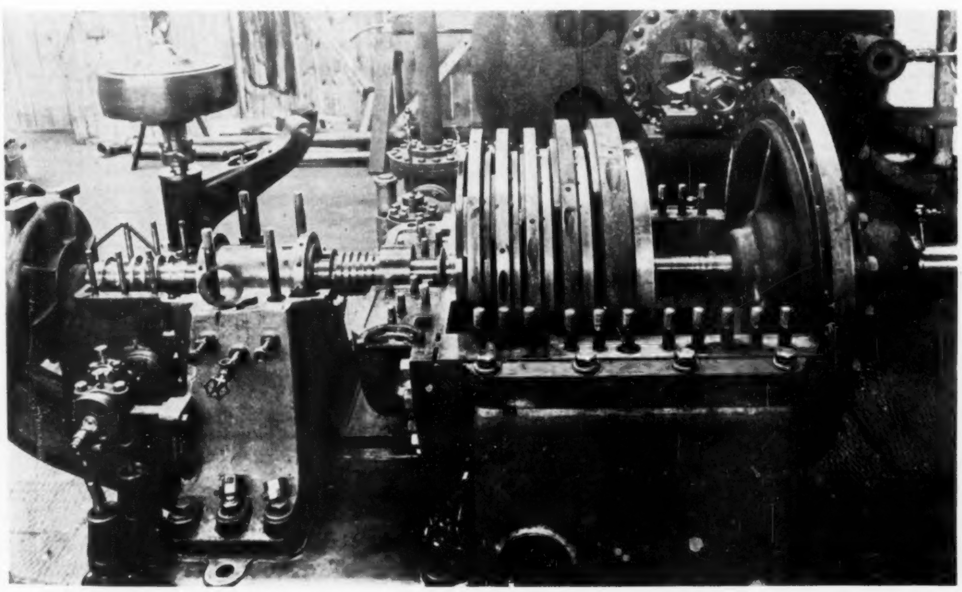

FIG. 6 PATITZ TURBINE WITH COVER REMOVED

About the same time an order for a 5000-kw turbine was received from the Brooklyn Edison Co. for the Gold Street Station.

THE SANKEY AND FULLAGER PATENTS

Reference has been made to these patents for which licenses were secured by Allis-Chalmers Co. from the Turbine Advisory Syndicate.

Capt. Riall Sankey (retired) was managing director for Willans and Robinson and invented and patented the swaged type of blade fastening used for many years by Allis-Chalmers Co. The Sankey patent covered the construction shown in Fig. 8.

The blades were cold-pressed at their bottom section into an open "L" dovetail shape so as to fit into a foundation ring which had slots of dovetail shape milled in it at the required pitch and angle for the blades. One portion of the base of the blade fitted the slot in the ring while the other portion lay along the tapered side of the base ring. This side of the base ring sloped outward so that it and the blade base would fit snugly into a dovetailed groove in the spindle or cylinder. The groove was closed by inserting a soft-metal strip on the side opposite the blade base and calking this into place by a hammer and calking tool. This construction formed a reliable method at that time for retaining the blade rows in place.

A feature of the Sankey blade construction was the use of a channel-shaped shroud

at the tip of the blades. The original form of blading as used by both Parsons and Westinghouse had the sawed-off end of the blade directly exposed at the tip. The radial clearances between this blade end and the casing or spindle had to be

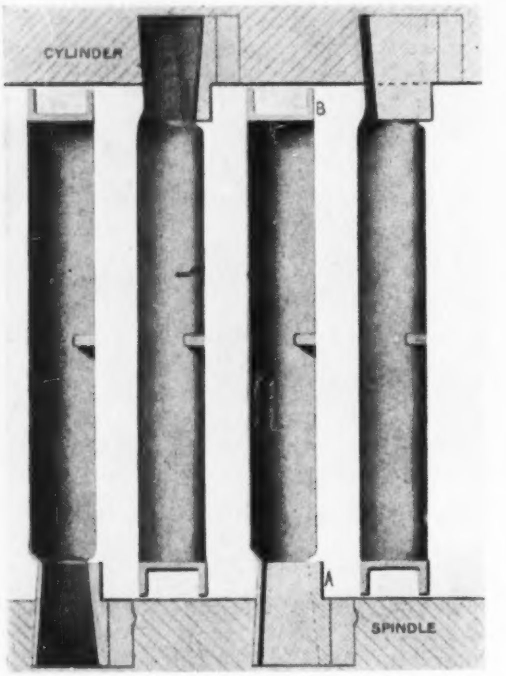

FIG. 8 TURBINE BLADING CONSTRUCTED ACCORDING TO SANKEY PATENTS

small on the Parsons original construction to avoid high leakage losses. Any deformation of spindle or casing would cause these blade tips to rub, resulting in the generation of heat. This heating caused the blades to elongate, which further aggravated the rubbing. Such rubbing frequently led to blade failure. If this did not occur, clearances over the blades would be excessive when conditions again became normal, due to wear on the blade tips from rubbing. Undue heating from violent rubs frequently caused the spindle to become bent. Sankey provided a channel-shaped shroud on the ends of the blades which shroud had two narrow flanges projecting beyond the blade tip. In case of a rub, these thin flange tips would wear away easily without causing blade vibration or heating, and hence blade failures were less liable to occur as a result of an occasional rub.

The original Sankey blading had a projection on the end of the blade entered through a punched hole in the shroud and then riveted over. This construction was used on a few early Allis-Chalmers turbines but was abandoned in favor of a construction in which the shroud was silver-soldered to the blade tip. Such a change was necessary as a patent was granted to General Electric Co. covering the riveting-over of a blade tip to hold a shroud.

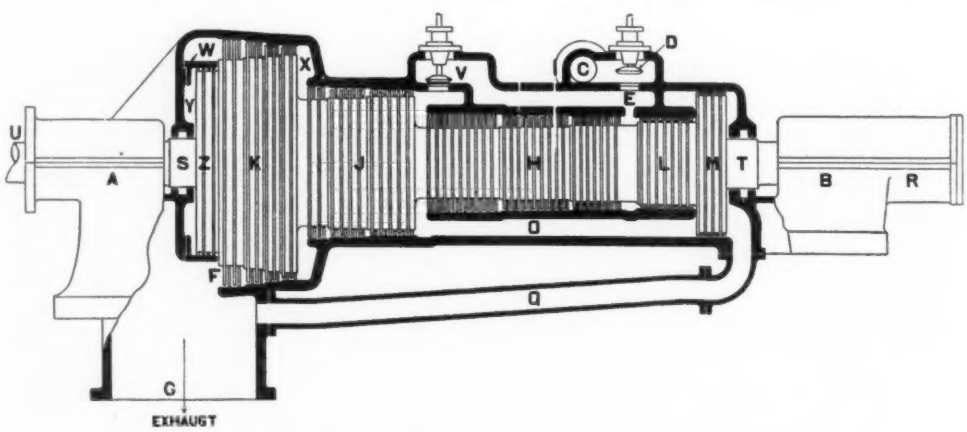

FIG. 9 CROSS SECTION SHOWING FULLAGER BALANCE PISTON MARKED *Z*

The end thrust due to exposed annular areas and to the difference of pressure across blade rows, is equalized on Parsons turbines by means of balance pistons whose surfaces are proportioned to provide equal thrusts in opposite directions. The early designs of Parsons turbines had the blades arranged on a series of cylinders—usually three—which were of varying diameter.

Each cylinder was provided at the steam-inlet end of the spindle with its respective balance piston. On large-size turbines, this resulted in an undesirable cylinder construction, since there was a large temperature difference and considerable pressure drop in a very short length of casing, and, due to the large size of the low-pressure balance piston, the casing form was such that deformation could scarcely be prevented.

Fullager patented a construction shown at *Z* in Fig. 9 in which the low-pressure piston was placed at the exhaust end and inside the base ring of the last row of blades. Communication between the rear of this piston and the corresponding pressure point before the low-pressure cylinder was obtained by holes through the web of the rings carrying the low-pressure blade rows. This construction is naturally not suitable for spindles that are solid forgings, but all the early units consisted of a shaft onto which at least the low-pressure blade rings were pressed. Clearances on the balance pistons at the high-pressure end were axial and were adjusted by the thrust blocks. The clearance on the Fullager piston had to be radial as the distance from the thrust blocks was too great and temperature changes too excessive for axial clearances. The Fullager piston resulted in a rugged cylinder construction and little trouble was experienced with cylinder deformation.

THE FIRST ALLIS-CHALMERS-PARSONS TURBINE

When the Murray orders were placed, the Allis-Chalmers Co. was definitely committed to the construction of steam turbines.

It is said that Fullager laid out the blade proportions of these first turbines and came to Milwaukee early in 1904 to design the blading for the 5500-kw turbine for Brooklyn. Fullager designed the high-pressure blading of liberal proportions and all of these machines later developed great overload capacities, though their efficiencies would have been improved by blading of less height in the high-pressure sections. Maximum tip speeds ranged from 300 to 400 ft per sec on these early turbines. Hence many stages had to be used that resulted in a long distance between bearings which offset the advantages of small diameters.

In April, 1904, Asa M. Mattice, then chief engineer of the Westinghouse Machine Company, was called to Milwau-

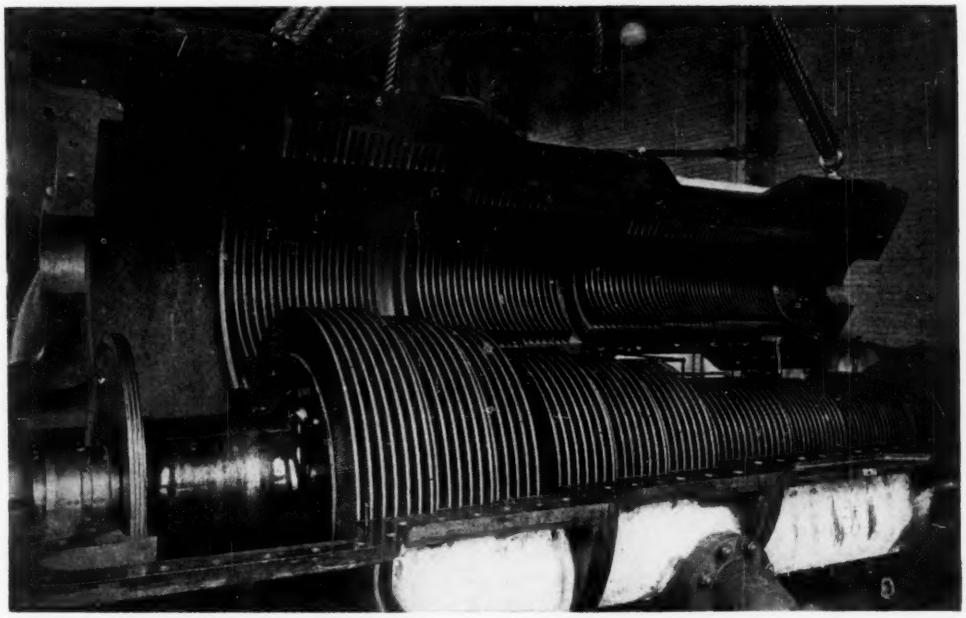

FIG. 10 CYLINDER AND SPINDLE OF THE UTICA 1500-KW TURBINE

kee to become chief engineer of the Allis-Chalmers Co. Mattice had been actively engaged with Westinghouse on the development, design, and construction of the Westinghouse-Parsons turbines and had become convinced that the steam turbine was destined to become the chief source of power supply in the rapidly growing electrical industry.

Mattice graduated from the Naval Academy, Annapolis, in 1874 and served as an instructor in steam engineering at the Academy. He became chief designer in the Bureau of Steam Engineering in 1887 and had a leading share in the development of the "New Navy." In 1890 Mattice was appointed principal assistant to E. D. Leavitt in charge of the designing of hoisting and pumping engines and of mining machinery. In 1900 he took the position of chief engineer of Westinghouse Electric Company and in 1903 was transferred by Mr. Westinghouse to the Westinghouse Machine Company as chief engineer. In 1906, he joined the consulting firm of Kafer, Warren & Mattice, and was retained as consulting engineer for Allis-Chalmers Co. Mattice died in 1925.

Mattice apparently took no part in the negotiation or sale of the first turbines to Murray and Brady nor in the initial arrangements with the Turbine Advisory Syndicate. He went to Europe in 1904 to consult with this syndicate and to negotiate with Parsons while at the same time he gathered many data on the later European developments in steam turbines.

The first turbine built by Willans and Robinson in their Rugby shops for Allis-Chalmers Co. was nominally rated at 1500 kw, 1800 rpm, and was shipped about May, 1905. This unit had been run at speed and balanced before shipment. No generator was available to test it under load as the generator was to be built by the Bullock Electric Co., Cincinnati, which concern had recently been acquired by Allis-Chalmers Co.

A. G. Christie, the author of this paper, had been for a number of years engaged with Westinghouse Machine Company on the construction, test, and erection of their steam turbines. An appointment as instructor in mechanical engineering at Cornell University was accepted in October, 1904. In March, 1905, Mattice telegraphed Christie to meet him and McKee in Milwaukee to discuss employment with the Allis-Chalmers Co. At this conference it was arranged that Christie would leave for England in two weeks to supervise the construction of the turbines at Willans and Robinson and to collect turbine data for Allis-Chalmers Co. from the Turbine Advisory Syndicate. Just before sailing date, this trip was canceled as a result of a discussion with C. A. Parsons & Co. over patents. During the summer of 1905, it was arranged to get turbine data from Parsons direct and to acquire American rights under the later Parsons patents. Arrangements were then made for Christie to take charge of the field erection of the first Allis-Chalmers turbines.

About June 1, 1905, Christie received a telegram to report to W. E. Richardson, then district superintendent of construction for Allis-Chalmers Co. in the Eastern district with New York as headquarters. Richardson had an office near the 59th Street station in which Allis-Chalmers Corliss engines of 5000 kw were being erected. He was at that time a confirmed engine man and mistrusted steam turbines. On reporting to Richardson, Christie was told that the 1500-kw Willans and Robinson turbine was being unloaded at the docks for shipment to Utica, N. Y., and that Mattice had wired that Christie was to receive instructions for handling erection. These instructions were: "Go ahead and put the —— thing up. It will never run anyway." Many of the reciprocating engineers connected with Allis-Chalmers maintained this critical attitude toward steam turbines for several years. This greatly increased the difficulties encountered in the construction and operation of the early units. It is interesting to note that a month or so later, Richardson resigned from Allis-Chalmers Co. and on joining the staff of Westinghouse Machine Company took charge of erection of their steam turbines. Samuel Moore succeeded Richardson in charge of the New York office and gave his hearty cooperation in the erection of the new steam turbines. Later Moore went to Milwaukee as superintendent of construction.

The first turbine, Fig. 10, was installed in the Washington Street station of the Utica Gas & Electric Co. As the foundations were ready, erection started on June 12, 1905. Christie was assisted by J. M. Larson, now superintendent of the West Allis shops, and by S. Matthews and F. C. Schmitter from the Bullock works.

This unit had a modified Fullager balance piston. During construction, the cover, which was hinged as shown in Fig. 9, and spindle were lifted and it was found that certain of the blade rows had rubbed sideways during one of the trial runs in England so that the blade openings in these rows were almost closed. McKee and C. Barth, who had charge of the turbine shopwork at West Allis, came to Utica and inspected the blading. On account of certain difficulties between Allis-Chalmers Co. and the Turbine Advisory Syndicate over patents and other matters, it was decided to operate the unit as received without attempting to correct the blading. When the unit was put on the load on Aug. 14, 1905, the maximum output that could be obtained was about 400 kw, owing to the stoppage of the blade passages. An excessive end thrust was also present. At this

time difficulty arose over the construction of a second turbine of 5000 kw by Willans and Robinson. The performance of the Utica unit caused the order for a second machine from England to be canceled and work was rushed on both the 5500-kw and 5000-kw units in the Allis-Chalmers shops at Milwaukee.

It was evident that something had to be done with the blading of the Utica turbine in order to secure the rated output. Apparently, no one wished to order changes to be made until the difficulties with Willans and Robinson were straightened out. After some delay Christie was instructed by telegraph to assume the full responsibility for putting the unit in first-class operating condition. Not having any design data at hand, probable blade openings were estimated and the blades adjusted to these figures, at the same time correcting for end thrust. When these changes were completed, it was found that the turbine would not only carry its rated capacity but that it would easily carry overloads up to 2500 kw. Christie's estimates of blade openings were too liberal for the blade lengths designed by Fullager.

The guarantees for the Bullock generator furnished with this turbine stipulated a temperature rise in the stator windings of 35 C after a 24-hour run at full load. The generator was amply supplied with copper and was ventilated by a motor-driven blower set. In actual service the temperature rise was only about 22 C under the rated load conditions of 1500 kw. Hence the generator was also able to carry large overloads continuously. This overload capacity was of real value at the Utica plant which at that time acted as a steam stand-by station to a hydroelectric plant at Trenton Falls in the Adirondack Mountains. Shortly after the turbine was finally adjusted, trouble at the hydroelectric plant necessitated the continuous operation of the steam turbine for three weeks before the hydro plant was back on the system. This run under all variations of load definitely established the commercial reliability of the Allis-Chalmers type of turbine and is a definite milestone in the development of this machine.

A notable feature of the Utica turbine was its bearings. It was common practice to furnish Parsons turbines with sleeve-type bearings placed in spherically seated shells to lessen the effects of vibration and permit alignment. The Utica turbine had babbitt-lined bearings, split in half, with no spherical seats or other devices to correct for misalignment. The product of velocity, in feet per second, and pressure, in pounds per square inch of projected area, was 3600, which greatly exceeded practice previous to that date. On erection these bearings were relieved at the sides to permit oil to be pumped in more readily by the shaft. This is believed to be one of the first applications of this construction of relieved sides to turbine bearings. These bearings gave excellent performance and on inspection about a year after acceptance, showed the original scraper marks over the whole surface. Representatives of other manufacturers frequently visited the Utica plant to observe bearing performance.

The original cooling device for oil furnished from England with this unit consisted of pipe coils placed in the large oil reservoir. The cooling water circulated through these coils. This arrangement was wholly inadequate and was replaced temporarily by a closed feedwater heater with copper coils through which the oil circulated. Finally, an oil cooler with small tubes through which the oil circulated was furnished from the Milwaukee works and gave excellent service. A reciprocating oil pump geared from the main shaft circulated the oil.

The Utica turbine was furnished with a powerful Hartnell governor which controlled the inlet valve through a direct lever. This regulator proved too sensitive for parallel operation with the water-power units and with steam engines in the same plant. The tendency to hunt was overcome by the addition of an oil dashpot which decreased the sensitivity of the governor.

Tests were made on this turbine to determine the differential expansion of spindle and casing under starting and stopping conditions and when sudden changes of load occurred.

The Utica turbine was provided with a new type of Connersville jet condenser, then being developed jointly by the late R. D. Tomlinson of Allis-Chalmers Co. and the late John Wilkin of the Connersville Blower Co. Its first operation was far from satisfactory and more study, trial, and effort were devoted at Utica to overcoming condenser troubles than to the steam turbine itself. The condenser was finally brought to a satisfactory operating condition and this development work led to the construction and use of many such units in later years.

It was the original intention to run elaborate performance tests on the Utica unit. The turbogenerator set was guaranteed to produce a kilowatthour at full load on 18.5 lb of dry steam furnished at 175 lb per sq in. gage and with a 28-in. vacuum. This corresponds to an engine efficiency of 55.4 per cent with about 10 per cent moisture at exhaust. The boiler plant at Utica furnished steam to the gas works and the piping was such that boilers and feed lines could not be isolated for turbine test. The jet type of condenser prevented condensate measurement. Furthermore, with the adjusted blades, the best load was just before the overload valve opened, at 2200 kw rather than at 1500 kw as per guarantee. The test program was therefore abandoned and the purchaser accepted this turbine on Dec. 6, 1905. Christie went to New York to supervise steam-turbine erection and operation.

About a year after this unit was accepted by the customer, one of the plant operating engineers started the turbine without proper heating in order to show off to his friends. This resulted in a badly bent spindle which had to be replaced. A rebuilt spindle with the old blading was returned to Utica and balanced in place. Many valuable data on field balancing methods in relation to critical speed were secured from this work.

THE 5500-KW TURBINE

On Nov. 25, 1905, J. H. Larson and S. Matthews started the erection at the Kent Avenue station of the Transit Development Company, Brooklyn, N. Y., of the first steamtur bine built in the Milwaukee shops and at that time one of the largest turbines in America. It was rated at 5500 kw, 750 rpm, 25 cycles, 6600 volts. It formed the first unit in the new station which was to furnish power to the elevated railroads in Brooklyn. Such service was subject to widely varying demands. The plant operating conditions were 200 lb per sq in. gage, 75 F superheat, and 28-in. vacuum. The turbine operated in parallel with a vertical reciprocating engine in the old Kent Avenue station adjacent to the new plant.

At the time that erection was started, the station was only partly finished, no windows or doors were in place, and there was absolutely no flooring. Erection was carried out under adverse conditions on temporary wooden platforms built about 25 ft above the basement floor. All material was handled into the plant from barges. When the generator field was being unloaded, its weight tilted the barge to such an extent that it started to roll and only the barge mooring ropes prevented it from going to the bottom of the East River. The stator of the alternator was too heavy to handle by this means and was therefore assembled on the job. When the generator stator was placed on the bedplate, it had to be covered with wire screens of fine mesh to prevent nails and other materials from dropping into the open frame, as building construction was still in progress.

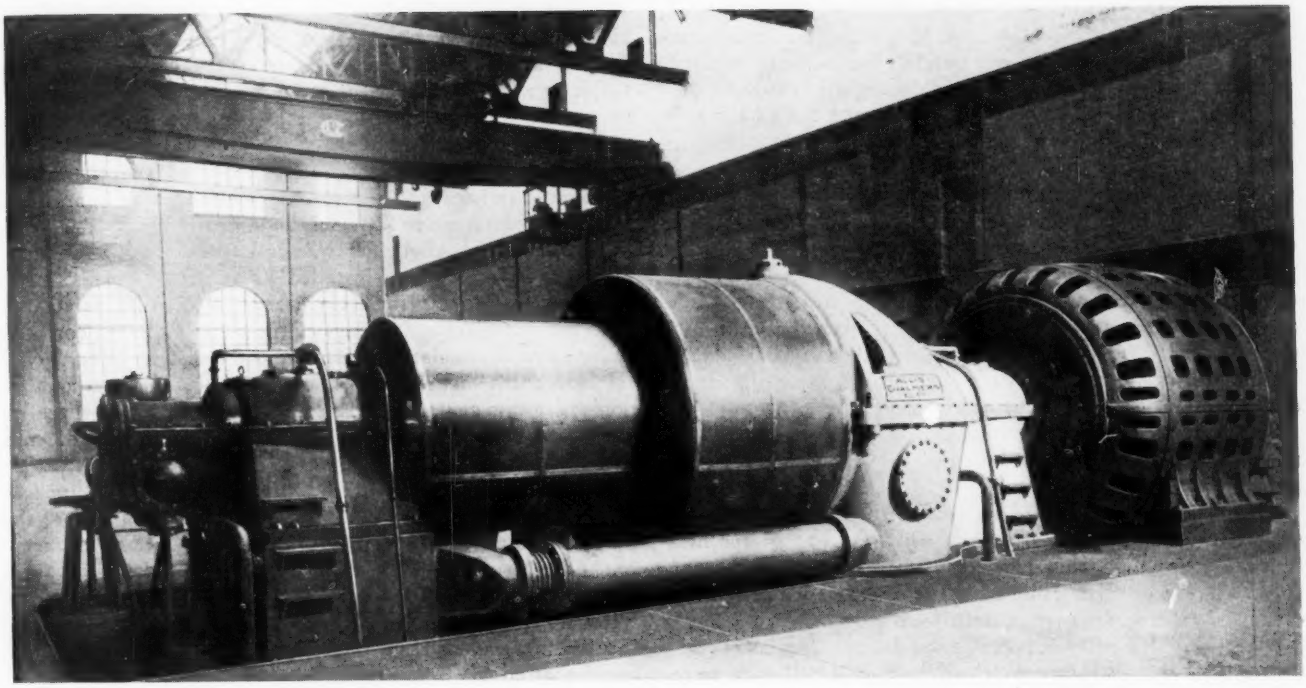

FIG. 11 THE 5000-KW TURBINE AT GOLD STREET STATION OF THE BROOKLYN EDISON CO.

In spite of handicaps of cold weather and lack of facilities, the unit was ready for steam by Feb. 1, 1906. The boilers and piping, were not completed until March 20. As soon as steam was available clearances were adjusted and a start was made on drying out the generator. A mishap in another power house on the morning of March 27 left the company short of power. The Allis-Chalmers unit was requested for the afternoon load. Although the unit had never been up to speed except in the shops before shipment and had never at any time been under load, it was checked out for dryness, brought up to speed, and given a load of about 4000 kw for the remainder of the afternoon. This performance of carrying 80 per cent of rated load within three quarters of an hour after being brought up to speed for the first time, while it seems rather tame to present-day engineers, was said at the time to have no equal in the history of central stations. The next day a load of 5000 kw was carried and on the succeeding day this reached 7000 kw. These performances attracted much attention and were widely discussed.

After service was restored in the older station, the turbine was opened up for inspection. The casings of some early Parsons turbines tended to bow up in the middle when subjected to superheat. The Allis-Chalmers turbine was provided with ribs to overcome this defect and inspection showed that this ribbing had been somewhat overdone. Slight blade rubs were noted on the top half of the casing. This was remedied by lowering the spindle by changing bearing-shims. The turbine was closed up and operated on loads up to 9800 kw until April 25, when a rub was heard inside the casing.

On opening up it was found that the blade of a jackknife had become wedged under the shroud of the first row of guide blades and acting as a turning tool had undercut the spindle and the calking strip of the first blade row to such an extent that the blade ring was loose. How the knife blade got into the turbine always remained a mystery. The first stationary and moving rows were removed and the turbine was returned at once to service without them.

Some months later some blades were broken in the last blade row, undoubtedly due to fatigue vibration, although this cause of failure was not recognized at the time. The last blade row was later replaced. These were the only blade troubles experienced on this unit.

This turbine was furnished with a governor provided with a single-action oil relay, all built at the Milwaukee shops. It was required to function on one of the worst railroad loads in America and was more sensitive than the governor of the reciprocating engine with which it operated in parallel. Readjustments of the governing mechanism were necessary to secure satisfactory regulation under load conditions.

The self-adjusting bearings of this unit were designed for water cooling. The water-cooling pipes were ordered on and off several times during erection but eventually these were left off when the unit was started. The bearings were eased at the sides as on the Utica machine and ran cool in service.

An inspector from the Milwaukee Works dropped into the plant when the erectors were easing the sides of the bearings. On his return to Milwaukee, he found no indication of such clearance on the drawings and started a row. A new duplicate set of bearings was made and forwarded with orders to use these without easing the sides. These bearings never reached the plant until months after the unit was in operation as a trucker conveniently "lost" them during the interval. After the satisfactory performance of the original bearings had been demonstrated, the second set was returned to Milwaukee and used in some later machine after proper relieving at the sides.

Many small troubles developed on this unit and it was not finally accepted until after about a year's operation. Shortly after the turbine was taken off the builder's hands and after all Allis-Chalmers engineers had left the plant, an accident occurred to the turbine which completely wrecked the unit. The exact cause of this trouble was never fully determined.

THE BROOKLYN EDISON'S 5000-KW TURBINE

The turbine shown in Fig. 11 was delivered on April 21, 1906, and J. T. Backus was placed in charge of its erection, in the Gold Street station of the Brooklyn Edison Co. This station had originally been built for horizontal Corliss engines. These

were removed, the crane and roof lifted, and turbines installed. Erection of the Allis-Chalmers turbine was practically completed before the new roof was put in place. Plant construction delayed applying load to this unit until July 1, 1906.

This unit contained many improvements on the earlier unit at Kent Avenue station. A Hartung governor with double-acting oil relay gave satisfactory regulation from the start.

A heavy thrust toward the steam end prevailed when the turbine was put under load. This was overcome by changing the size of the low-pressure Fullager piston which was a comparatively simple matter. In order to check the thrust against the pull on the thrust-block lever and also to determine the correct size of Fullager piston, a valve was placed in one of the pressure-equalizing pipes and readings taken under varying load conditions. Valuable data that proved useful in future designs were secured from this arrangement.

Stage pressures under all load conditions were also determined by suitable pressure and vacuum gages. These data were also applied in later designs.

Difficulty was encountered with the growth of cast iron in the valve parts due to superheat. This was one of the first instances in which this phenomenon was closely observed and rates of growth determined. These studies led to modifications of valve design to provide for such growth.

All early Allis-Chalmers turbines had difficulties with the adjustment of the secondary overload valves. Until data were accumulated on pressure-load conditions in the various turbines, these had to be set by cut-and-try methods.

The Brooklyn Edison turbine was shut down several times in its early operation by slugs of water coming over from the bare steam pipes which were later covered. This water caused no apparent damage to the blading.

The alternator of this unit had an open frame like the Kent Avenue generator. The end turns of the coils in these frames were held in place by porcelain insulators. In Kent Avenue certain of these insulators were cracked by a heavy short-circuit and were later replaced by block supports. The Brooklyn Edison alternator received a bad short-circuit from lightning which broke many insulators. Temporary repairs were made with cord and hardwood braces the next day and the alternator ran for many months in this condition before permanent blocks were put in place. The exciter rheostat and switch were destroyed by this short circuit, though the revolving field was undamaged. The rheostat and switch for the field of a neighboring Westinghouse unit then under construction were temporarily wired up and used until a new rheostat and switch could be secured.

Both this and the Kent Avenue turbines were furnished with water-sealed glands, and this has been standard practice on Allis-Chalmers condensing turbines ever since. Both alternators were provided with fans built on each end of the revolving fields to provide generator ventilation to the open frame. This practice was followed for many years on Allis-Chalmers generators even after the frame was closed. Both Kent Avenue and Gold Street turbines exhausted into surface condensers neither of which were furnished by Allis-Chalmers Co. The Brooklyn Edison unit was accepted by the customer on Dec. 31, 1906.

THE NEW YORK EDISON CO. ORDERS 1500-KW TURBINE

While the large units were being erected in Brooklyn, a steam turbine of 1500 kw capacity was under construction by the late F. L. Neely at the Bronx station of the New York Edison Co. on Rider Ave. This unit operated at 1875 rpm and 2500 volts. It was placed in an old station among reciprocating engines.

The customer insisted on a barometric type of condenser for this unit of which Allis-Chalmers Co. only supplied the condensing head. The customer provided the U-bend below the turbine and the interconnected piping all of which was spring-supported. It developed that proper provision for expansion and bracing had not been made for the condenser swayed so badly the first time the turbine was run at speed, that the turbine frame was twisted and the spindle became badly bent. The spindle was returned to Milwaukee for repairs.

The barometric condenser was taken down and a Connersville jet condenser was installed as at Utica. This latter worked satisfactorily for a time when it was discovered that both the impellers and casings of the pump had been corroded badly by acid circulating water from the Harlem River. The intake for this supply was below a coal-unloading pier and undoubtedly this contributed largely to its acidity. Eventually, the pump was furnished with impellers and casing of hard bronze which lasted for some years.

An amusing incident occurred shortly before this machine was accepted. One afternoon, an hour or so before the time of the peak load, the turbine lost its vacuum and operated noncondensing at a greatly reduced output. Investigation showed that no water was available at the water glands on the spindle. This water was taken from the drinking-water supply of New York City which was also the source of boiler feedwater. It was found that no city water was available anywhere in the whole station. An emergency by-pass around the meter was opened and service both to boiler feed pump and to turbine glands was quickly restored. When the meter connections were opened up, a large eel was found wedged in the meter; an entirely new instrument was necessary.

This turbine was accepted in March, 1907.

A 1500-KW TURBINE FOR THE WESTCHESTER LIGHTING CO.

About the same time as the Bronx unit was being started, a 1500-kw 1800-rpm turbine shown in Fig. 12, was erected by R. L. Cummings at the New Rochelle Station of the Westchester Lighting Co. Its generator is believed to be one of the first units wound for 13,200 volts. The open-frame construction was still retained. Corona was visible on the windings of this unit and at night the alternator had a ghostly appearance.

The turbine was furnished with steam from hand-fired Stirling boilers. The superheat was the highest that had been supplied to turbines up to that time. The opening of the furnace doors for hand firing caused great variations in superheat which made the turbine speed surge under load. This was finally remedied by modifications in the firing system and by damper controls.

This unit was also provided with a Connersville jet condenser with which no major trouble was experienced. An official test was made on this turbine. At 1500 kw its steam consumption exceeded the guarantee by about 1 lb of steam per kwhr. At 2200 kw the performance was better than the guarantee. Either the spindle had to be changed to give a better steam consumption at 1500 kw or a new generator had to be provided of 2200 kw rating. As the customer needed capacity, it was finally agreed about the end of 1907 to accept the turbine without either spindle or generator changes.

OTHER 1500-KW TURBINES

The remaining two turbines on the original Murray order were installed during 1906–1907 at the plants of the Memphis Consolidated Lighting and Power Co., Memphis, Tenn., and of the Dayton Lighting Co., Dayton, Ohio. No unusual ex-

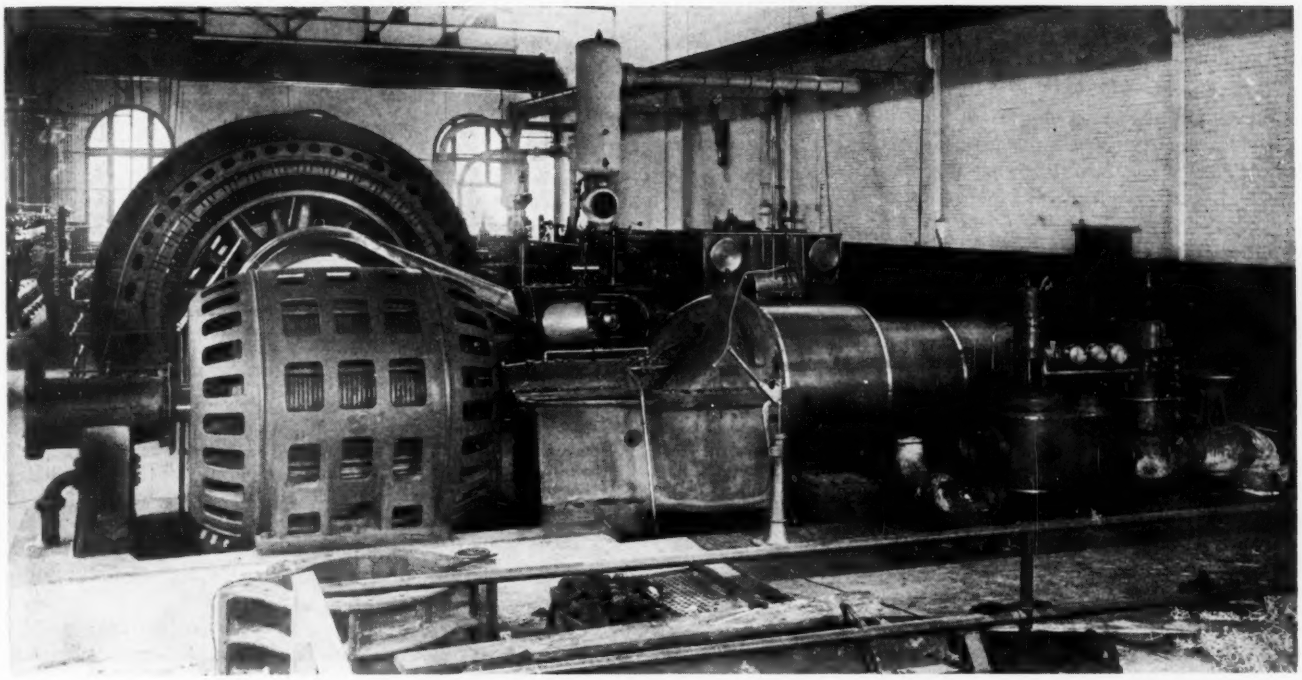

FIG. 12 1500-KW TURBINE FOR WESTCHESTER LIGHTING CO.

periences were encountered in the erection of these two units.

All turbines on the Murray order had open-frame generators and consequently were noisy.

One of the early troublesome problems of all these turbines was that of securing a proper lubricating oil. The necessary properties of a turbine oil were not well understood and much trouble was experienced from foaming, acidity, and sludge formation with the oils then available.

Another trouble on these early units was connected with the sliding of the free steam-end support due to temperature changes in the casing. This base was constrained on the sides by gibs and on the Utica and Kent Avenue units was at some distance below the center line of the bearing. This resulted in uneven travel from temperature changes which tended to deform the cylinder. The difficulty was overcome in later designs by bringing this sliding surface quite close to the center line of the bearings and by pitching the supporting base slightly toward the exhaust to allow for temperature changes and to provide a parallel surface on which to slide. Brass sliding pads were furnished for all such surfaces on later units.

Comparatively little difficulty was experienced in the operation of these turbines subsequent to the first few units. This was due largely to the high personal skill of the erecting engineers and also to the preparation under Christie's direction of a manual covering all details of erection and operation. This manual was kept strictly up to date. Erecting engineers were kept informed of experiences with the various turbines and were thus able to avoid many difficulties that might otherwise have developed.

LATER TURBINES

The operating records of the pioneer units which have been described led to many orders for steam turbines. The first 500-kw steam turbine built by Allis-Chalmers Co. was installed by C. C. Moore in the plant of the Western United Gas and Electric Co., Aurora, Ill., in 1906. An official acceptance test was made on this unit and it bettered its guarantees by about 9 per cent. Patitz and Moore witnessed the test for Allis-Chalmers Co. During one test at about 112 per cent rating at 4 a.m. the turbine stopped inside of a minute. Every one expected a wrecked machine with "blade salad" and a bent spindle. The boiler tender had gone to sleep with the boiler feed pump running full speed and boiler, piping, and turbine were full of water. No harm was done to the turbine and the tests were completed after getting rid of the water.

Before the depression, in September, 1907, units of 500 kw capacity had been erected at the plants of the following interests: City of Jacksonville, Jacksonville, Fla. (two units); Interstate Railway Co., Wilmington, Del.; Meriden Electric Co., Meriden, Conn.; Canton Light Heat and Power Co., Canton, Ohio.

At the same time, 500-kw turbines were under construction in the shops for: Jamestown Woolen Mills, Jamestown, N. Y.; Bisbee Improvement Co., Bisbee, Ariz.; Brush Electric Light & Power Co., Galveston, Texas; Binghamton Light Heat & Power Co., Binghamton, N. Y.; Light Heat & Power Co., Northampton, Mass.; Savannah Lumber Co., Savannah, Ga.; Calumet and Arizona Mining Co., Bisbee, Ariz.

A turbine of 750 kw capacity was furnished to the Flatbush Gas Co., Flatbush, L. I., about January, 1907.

By December, 1907, turbines of 1000 kw capacity were under construction for or installed in the following plants: Kokomo, Marion & Western Traction Co., Kokomo, Ind.; National Cash Register Co., Dayton, O.; Illinois Steel Co., South Chicago, Ill. (two units); Western Canada Cement & Coal Co., Exshaw, Alberta, Canada (three units); Indianapolis, Newcastle & Toledo Ry., Indianapolis, Ind.; Citizens Light Heat & Power Co., Johnstown, Pa.; Delaware, Lackawanna and Western R.R. Co., Scranton, Pa.

Turbogenerator sets of 1500 kw capacity were built before the end of 1907 for: Helderberg Cement Co., Howe's Cove, N. Y.; American Thread Co., Watuppa, Mass.; The Milwaukee Electric Railway & Light Co., Milwaukee, Wis. (three units); and a 3250-kw unit for Virginia Passenger and Power Co., Richmond, Va.

About this time the Brooklyn Edison Co. placed an order

for a second unit of 6000 kw for installation in their Gold Street station. This purchase was made on the basis of the excellent operating record of their earlier 5000-kw Allis-Chalmers unit.

Many improvements in the construction of these units developed from the experience gained in the operation of the earlier turbines. Governor gear was made more reliable, oil systems more foolproof, and other details were likewise improved.

The first 500-kw units were built with the Parsons sleeve bearings. It was impossible to prevent excessive vibration on the Wilmington, Del., unit until these sleeve bearings were replaced by spherically seated babbitt-lined bearings. Thereafter, only the babbitt-lined bearings were used on all units.

The three 1500-kw Milwaukee Electric Railway turbines were the first large noncondensing units built by Allis-Chalmers Co. These were installed in the basement of the Public Service Building, Milwaukee, and furnished steam to the large, underground, central-heating system of the city.

The Exshaw turbines were built on a rush order and shipped West. They lay in the open for many months after arrival before their foundations were ready. One of these turbines would at times vibrate badly and at other times would run smoothly. After about five years of operation, this turbine stripped some blade rows. It was then found that one of the wheels carrying the low-pressure blades had one keyway cut off center. Instead of providing an offset key on the shaft, the wheel had been forced over a straight key during assembly in the shops. This evidently deformed the shaft. After an offset key was provided no further vibration trouble was experienced. In spite of bad dust conditions, these generators operated satisfactorily until the War, when they were moved to a war plant in the East.

All of the alternators of turbines after the Murray orders were of the enclosed type, taking air for cooling the generators at the bottom of both ends of the frame and discharging the heated air from the central top section of the stator into the turbine room. It is believed that the Meriden unit was the first in which the air supply was drawn from outside the power house.

It was common practice to start these early units noncondensing and to apply vacuum only when the speed was sufficiently high to seal the water glands. It was not an unusual occurrence to lose vacuum under load due to difficulties with the condensing system. This did not seem to affect the operation of the turbine beyond causing a reduction in load-carrying capacity.

All turbines and alternators had ample overload capacity and it was not infrequent to guarantee continuous operation at 25 per cent above normal rated capacity with no greater temperature rise in the generator than is now standard practice at normal rating.

As previously stated the Murray turbines based on Fullager designs were proportioned with too great blade lengths in the high pressure stages. This developed large overload capacity but was not conducive to high efficiency. This condition was corrected in all later turbines, many of which on official tests bettered their guarantees by steam consumptions which were from 5 to 10 per cent less than the stipulated rates.

Allis-Chalmers made it a practice on all these early turbines to provide foundation bolts for the bedplates of which there were two. One supported the sliding steam end of the turbine and formed the oil reservoir on the larger units; the other supported the exhaust end of the casing and the alternator with its bearings.

PATENT LITIGATION

Early in 1906, the Hudson and Manhattan Co. which was constructing tunnels under the Hudson River, announced that it would be in the market for a number of large turbines for their projected power plant. The choice appeared to lie between units built by Westinghouse and by Allis-Chalmers. At this juncture, the Westinghouse Machine Company entered suit against Allis-Chalmers Co. for infringement of patents on steam-turbine construction.

Mr. George Westinghouse had purchased some ten years before a group of Parsons early American patents on steam turbines and had added to these a considerable number of patents covering inventions by himself and his associates. The Kent Avenue 5500-kw unit was the basis for these infringement suits. Certain detail constructions used in the Kent Avenue turbine were claimed to infringe the patents held by Westinghouse. Strange to say, although this turbine was inspected several times by Westinghouse engineers in connection with this suit, they failed to observe the construction of one detail which was a straight infringement of one of the strongest Westinghouse patents. The other peculiar fact was that this particular patent was never cited against Allis-Chalmers nor entered into the suit.

A. M. Mattice took personal direction of working up the defense for Allis-Chalmers and Christie was detailed to assist him. Before the suit came to trial, the Hudson & Manhattan engineers decided not to become involved in the controversy and placed orders for their turbines with the General Electric Co. Shortly thereafter the patent suit was dropped and the early Parsons patents never came before the courts for adjudication.

PERSONNEL

Since the success of the Allis-Chalmers turbines was largely due to the skill displayed in their design and building, the men largely responsible for this should be mentioned. Reference has already been made to A. M. Mattice and R. A. McKee. After Mattice left the company, Max Rotter ably directed the steam-turbine department for many years. Max Patitz, as consulting engineer for the company, rendered invaluable service. Designs were largely due to L. W. Bailey, Jas. Wilson, Hans Dahlstrand, A. C. Flory, and R. B. Williamson. The shop work was under the direction of C. Barth assisted by J. R. McClure, James Moore, and others.

The construction department which had charge of erection and test was under the able direction of Samuel Moore at Milwaukee. Chas. Larson had charge of the New York office, Chas. McDonald of the Chicago office, and Chas. Paschedag of the Pittsburgh office. Among the field erectors not already mentioned were Messrs. H. L. Watson (now of DeLaval Steam Turbine Co.), C. L. Vickey (deceased), A. C. Ree, A. Ostberg, A. von Bergen, J. W. Grigg, Fred Buch, J. A. Raidabusch (now with Westinghouse Electric and Manufacturing Company), Chas. Yates, G. Pitcher, F. Hamilton, and others.

Christie, who was then assistant to Moore at Milwaukee, went to Alberta in the fall of 1907 to take personal charge of the erection of the three turbogenerators and two engine-generator sets delivered almost a year earlier to the Western Canada Cement and Coal Co. at Exshaw. On Dec. 1, 1907, a contract was closed by which Christie undertook to operate this Canadian plant for a year and this agreement terminated his services with the Allis-Chalmers Co.

Besides the previous acknowledgment of information furnished by Patitz, Rotter, and Orrok, the writer wishes to express his thanks to the Allis-Chalmers Manufacturing Co. and to A. C. Flory and Jas. Wilson of that firm for providing illustrations, data, and other information.

DIESEL-ENGINE-MAINTENANCE, OPERATING, *and* OUTAGE DATA

By LEE SCHNEITTER

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MANY QUESTIONS asked about Diesel-engine operation are difficult to answer because so few statistics from actual plants have been available. Little effort has been spent collecting information other than production-cost data. Engine manufacturers do not have funds for obtaining research data necessary to verify operating results, and users of engines seldom trouble themselves to keep adequate records.

The purpose of this paper is therefore to make accessible to Diesel engineers, operators, and prospective purchasers, information assembled by the author in the course of studies relating to certain important operating problems; it is hoped also to encourage others to undertake investigations of similar nature.

CYLINDER-LINER WEAR AS RELATED TO FUEL USED

Invention of the Diesel engine was a remarkable achievement, and development that has taken place during recent years —including simplification of design and use of better materials of construction—has been rapid. Even in its improved state the Diesel engine is subject to wear and physical depreciation during operation, like all other machinery. One of the large and expensive parts of a Diesel that undergoes rapid wear is the cylinder liner. Engine manufacturers are continuing their efforts to improve liners in order to reduce wear, but still the user pays the bill when liner replacements are necessary.

A review of the findings of both practical experience and scientific research shows that liner wear can be attributed to a number of causes. Some of these are: Unsuitable materials for rings and liners, incorrect design of rings, liners, and pistons, excessive pressure between ring and liner, caused by gas pressure behind the ring, inadequate lubrication, dilution of cylinder lubricant by fuel, absorption of lubricant by carbon deposits, excessive temperature of rings, excessive temperature of liners, chemical action causing corrosion, abrasive matter in the air, and abrasive matter in the fuel.

Some progress in reducing causes of liner wear has been made in recent years by changes in design of pistons, rings, and liners and by use of better materials. The last item, liner wear from abrasives in fuel used, is to a large extent beyond engine manufacturers' control.

A few operators have prepared charts showing liner-wear readings, and certain data have been presented from time to time, indicating the importance of grade of fuel used in relation to engine performance, but few or no data are available to show the effect of fuel on liner wear. The author's experience with Diesel engines using a great variety of fuels has furnished data on liner wear, shown in Fig. 1. Liner wear, which is the mean wear in each cylinder, taken at point of maximum wear (near top of piston-ring travel) was averaged for all cylinders of engines and is shown in thousandths of an inch as the ordinate. The average values for 8000 and 16,000 engine running hours are plotted against ash content of fuel (per cent by weight) as the abscissa. All these data have been obtained from generating stations with regularly operating slow-speed stationary Diesel engines of both two- and four-cycle types; cylinder sizes in most cases were 16 in. in diameter and larger.

The curves show how rapidly liner wear increases when fuel contains over 0.05 per cent ash; a vertical line drawn at this value is marked "Maximum Ash Content for Reasonable Maintenance Cost." It is also to be observed that rate of liner wear during the second 8000 hr running time is less than during the initial running period. A horizontal line has been drawn at 0.130-in. wear, to indicate allowable wear before liners should be renewed. A second line at 0.180-in. wear is marked "Maximum Liner Life," which means that engine operation with liner wear approaching this value will be unsatisfactory. It is possible to show from these curves that if a fuel with 0.03 per cent ash were used, the life of liners might be as much as six to eight years, while if a fuel containing 0.08 per cent ash were used the life would be no greater than two years maximum. These life periods have been proved in actual practice.

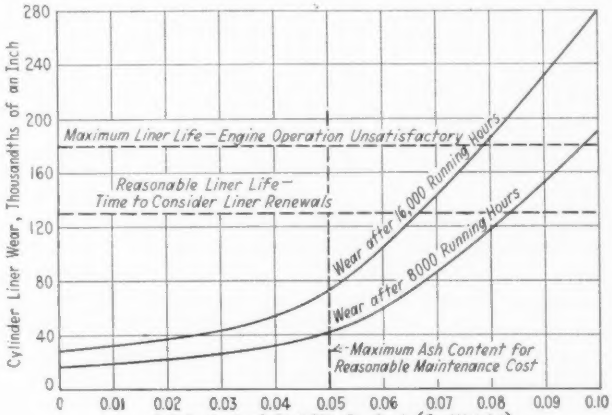

FIG. 1 CYLINDER-LINER WEAR FOR LARGE DIESEL ENGINES AS RELATED TO ASH CONTENT OF FUEL

(Wear is average of measurements taken in all cylinders at location of maximum diameters.)

EFFECT OF WEAR ON DIESEL-ENGINE CAPACITY

We all know that according to methods of rating used, a Diesel engine has little overload capacity, and continued operation of an engine at or near its rated capacity, even when new, will incur excessive maintenance expense. It is important for the user to know how much reduction in engine capacity may be expected as a result of liner wear and aging of the engine after a certain period of operation. Extra engine capacity should be purchased to compensate for this; otherwise the

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engine will fail to carry load for which it was intended, or if forced, will operate under abnormally high temperature, pressure, and fuel consumption, making it uneconomical.

We all realize that wear inevitably takes place, and when this happens there must be some decrease in engine capacity. We have all heard varying statements regarding magnitude of loss in power in an engine due to wear, but no one to the author's knowledge has prepared actual figures showing what the values really are. The upper curve in Fig. 2 shows some actual data on loss of capacity during operation. This particular station contained several slow-speed, stationary Diesel generating units with total capacity of 3000 kw. The plant was operated in conjunction with a transmission line, and continuous operation at rated capacity was expected. After the plant was started,

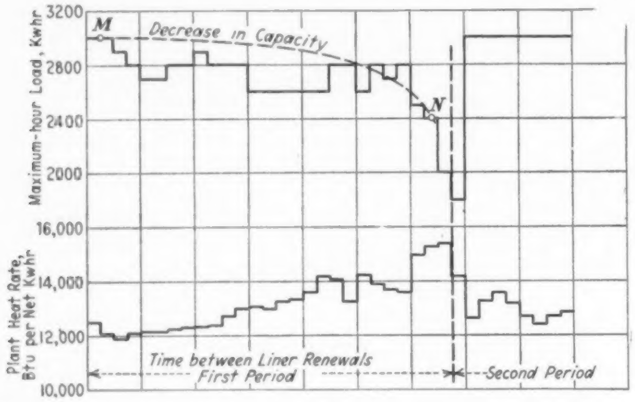

FIG. 2 DECREASE IN DIESEL-PLANT CAPACITY CAUSED BY WEAR

it was decided to reduce the rating to 2800 kw for safe and economical continuous service. Maximum hourly loads, in gross kilowatts carried by the plant, plotted for equal time intervals, between initial starting period and time when liners were first renewed, are shown in Fig. 2. It can be seen that the maximum-hour capacity available from this plant, at the time it was decided to replace liners, was 2400 kw gross. This reduction in capacity of the plant is of the magnitude of 20 per cent as compared to actual plant rating, and about 15 per cent as compared to the assigned safe running capacity. Maximum-hour loads of 2000 and 1800 kw shown on the curve occurred during overhaul period and are not considered representative; attention is called to return of plant to rated capacity and a much improved heat rate after liner renewals and other repairs were completed.

The important conclusion from upper curve in Fig. 2 is that the falling off in capacity due to liner wear (and other physical deterioration) would have required the purchase of 3750 kw of engine capacity to serve a load of 3000 kw, after wear of liners has taken place. Had the plant been serving a 3000 kw isolated load, this extra capacity should have been provided, or else new engine capacity would have become necessary before liner wear reached the stage of causing excessive loss in power.

EFFECT OF WEAR ON DIESEL-ENGINE EFFICIENCY

Engine wear, and particularly liner wear, also has a marked effect on engine efficiency. When a Diesel is purchased the engine manufacturer guarantees certain fuel rates at full, three-quarter, one-half, and one-quarter engine loadings—based on operation when engine is new and in first-class mechanical condition. Too frequently Diesel engineers and consultants make estimates with heat-rate figures that cannot be maintained during the life of an engine. The manufacturer's guarantee figures in pounds per brake horsepower-hour must be multiplied by 1.34 to convert to equivalent pounds per kilowatthour; the resulting figure must then be divided by generator efficiency and corrected for exciter losses (including windage and friction), for losses due to power consumed by engine auxiliary equipment, and by some factor representing loss due to starting and stopping (idle running of engine without generation). All computations so far give the equivalent consumption in pounds per net usable kilowatthour generated and if multiplied by the heating value of the fuel oil used (around 19,000 to 19,500 Btu per lb) give the station heat rate in Btu per useful kilowatthour with new engines. To arrive at a fair heat rate over the life of the engine or period between liner replacements, a wear factor must be considered. All engineers with Diesel experience will admit that some falling off in efficiency occurs, but no one has ventured to determine whether this be 1 per cent or 30 per cent.

The lower curve in Fig. 3 has been plotted from data obtained from a plant containing slow-speed stationary generating units and it is believed these data are typical for similar engines sold today. Plant heat rate per net kilowatthour output is plotted as ordinate and the abscissa scale represents time covering the period from initial starting of plant to that when liners were first replaced. The upper curve in Fig. 3 shows net kilowatt-

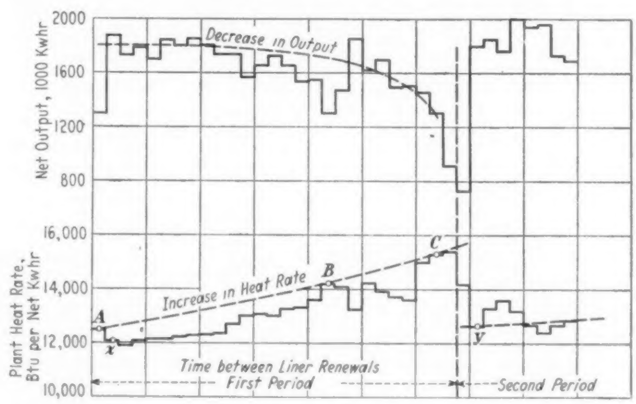

FIG. 3 INCREASE IN DIESEL-PLANT HEAT RATE CAUSED BY WEAR

hour output of this same plant for regular intervals during this same period. The heat-rate curve shows (point A) that this plant started with a heat rate of 12,500 Btu per net kwhr for an output of 1,300,000 kwhr. At a later period (point B) when this same output was produced, the station heat rate had increased to 14,200 Btu and at a still later date (point C), when liners were at the end of their normal life, the heat rate increased to 15,300 Btu for practically this same output. The curve also shows how economy was improved after replacing liners in both units; however, comparison of points X and Y show that heat rate after replacement of worn liners was about 4.5 per cent greater than the value when the plant was new. This increase evidently represents a loss due to physical wear and tear of the engine, and is to be expected. The increase in heat rate from time plant was initially started to time liners were replaced is 22 per cent; in other words, the average increase in heat rate between liner renewals should have been figured at about 11 per cent. The upper curve in Fig. 3 showing kilowatthour output also indicates the reduction in capacity of plant mentioned previously in Fig. 2.

DIESEL-PLANT LABOR REQUIREMENTS

Efficiency and safe operation of Diesel engines depend to a large extent upon operating and maintenance labor employed. It is seldom correct to assume that no operating labor need be

charged against a Diesel-engine installation. Even a small or moderate-size plant requires considerable attention. Neither can unskilled mechanics successfully service and maintain Diesel equipment. The author's extensive experience with Diesel plants has demonstrated that in any properly operated plant, only adequately trained and experienced operators are used.

Regular Diesel-engine attendants are required to start and stop units and to unload and handle deliveries of fuel, lubricating oil, and other supplies. During the running period, attendants must periodically refill the day-service fuel tanks and engine lubricators, operate the lubricating-oil purification system, regenerate the make-up water softener, make regular observations of temperatures and pressures, and keep the station records. In multiple-unit plants operators are also required to maintain correct load distribution among units and to operate the switchboard. Part-time attendants are sometimes provided in small plants, but if operators are to make regular inspections of equipment operating, they seldom can perform any great amount of other useful work.

The number of men required to operate and maintain a Diesel plant naturally depends upon the number and size of units operating, and on the operating schedule. The curves for plant

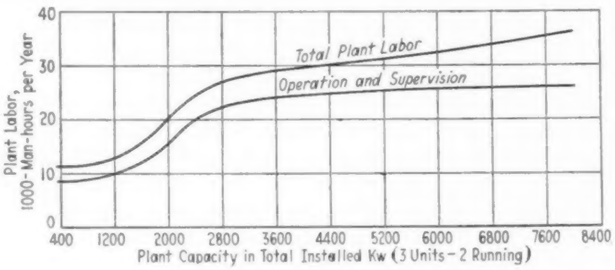

FIG. 4 DIESEL-PLANT LABOR

(Average for generating plants with three units installed but only two running. Plants giving continuous service 24 hr per day.)

labor (operating and maintenance) shown in Fig. 4 were prepared from data which have been averaged for a large number of Diesel generating stations containing about three units each, with two units operating. The plants were in full-time service (24 hr daily) as either isolated or base-load stations on interconnected systems. In Fig. 4 the vertical scale is thousands of man-hours per year and the horizontal scale covers plant capacities from 400 to 8000 kw total installed. The lower curve shows thousands of man-hours per year for regular operating labor and supervision, while the upper curve shows total plant labor. The space between these two curves thus represents maintenance labor. There is a rapid increase in plant labor as size increases, in the range from 1600 to 2400 kw installed capacity; for plants above 3200 kw (up to 8000 kw) there is a slightly increasing demand in man-hours for operating labor but a much higher demand for maintenance labor. In other words, maintenance labor becomes a higher percentage of total plant labor as size of plant increases.

DIESEL-PLANT MAINTENANCE DATA

There is doubtless more divergence of opinion regarding cost of Diesel-engine maintenance than on any other item of operation. Much of this confusion about maintenance costs is because figures received from different plants are seldom comparable. Type of plant, number of units installed, load conditions, operating time, operating and maintenance personnel, grade of fuel used, and many other conditions have a marked influence on maintenance costs. It is certainly unreasonable to compare maintenance costs in a plant operating at high load factor, with those in one operating at low load factor, or a plant operating on low-grade fuel oil with one operating on high-priced gas oil. Furthermore, maintenance costs are not representative for any plant unless they are collected over a period of time which covers a full cycle of liner replacements and general overhaul. Experience today shows that outage for routine inspection of engines must be definitely provided for, and plants that operate with systematic maintenance schedules in force give higher serviceability and reduced maintenance costs.

Maintenance for Diesel generating stations, as referred to in this paper, includes expenditures made for materials and labor for keeping total plant—including engine-generator sets, plant auxiliaries, electrical equipment and switchboard, and plant building and grounds—in safe and efficient operating condition.

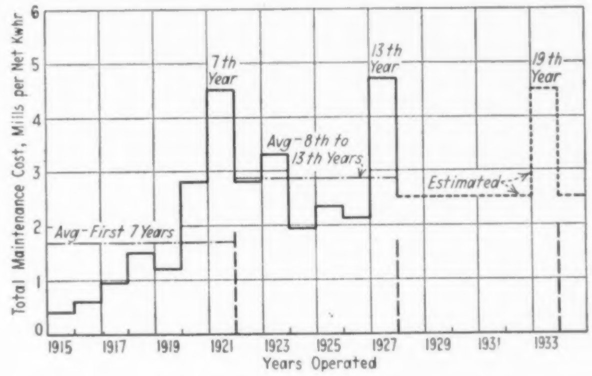

FIG. 5 DIESEL-PLANT MAINTENANCE COST BY YEARS FOR DIESEL GENERATING STATION WITH THREE UNITS OF 330 KW EACH

(Operating on Diesel oil of 24 deg A.P.I. All three units operated continuously at high capacity factor.)

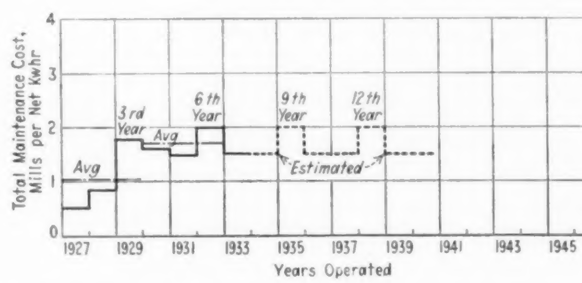

FIG. 6 DIESEL-PLANT MAINTENANCE COST BY YEARS FOR LARGE DIESEL GENERATING STATION

(Operating continuously at high capacity factor on bunker C fuel.)

The characteristic cycle of maintenance costs, with peak occurring when cylinder liners and major overhaul are necessary, is illustrated in Fig. 5. This curve shows maintenance costs in mills per kilowatthour net output, plotted by years, for a Diesel generating plant containing three units of 330 kw each. Engines in this plant were considered one of the best designs of the time, and plant was operated with a competent crew under good supervision. All three engine units were operated continuously on a 24-hr basis at nearly full rated capacity. Regular Diesel fuel having a density of about 24 deg A.P.I. was used. Particularly to be noted is the gradual increase of maintenance cost after the first year, reaching a peak in the seventh year when all three units were overhauled. Average maintenance cost during the first seven years was 1.7 mills per kwhr. After overhaul, maintenance did not return to the low level of the first seven years, but averaged 2.85 mills for the next six-year period. A second maintenance peak occurred in the thirteenth

year. Shortly thereafter the plant was dismantled and the dotted lines in the curve represent estimated maintenance cost only.

Actual maintenance cost, in mills per kilowatthour, is shown in Fig. 6 for a large Diesel generating station containing two units, operated on bunker C fuel oil averaging 12 to 14 deg A.P.I. This station was also operated continuously at nearly full rated capacity. The curve shows that maintenance peaks occurred every *third* year, owing to greater wear and more frequent liner replacements necessitated by use of heavy fuel oil. Dotted lines for maintenance costs after the seventh year are estimated, because the plant was placed on stand-by. Average maintenance cost for the first three years was 1.04 mills per net kwhr, and for the second three years was 1.70 mills.

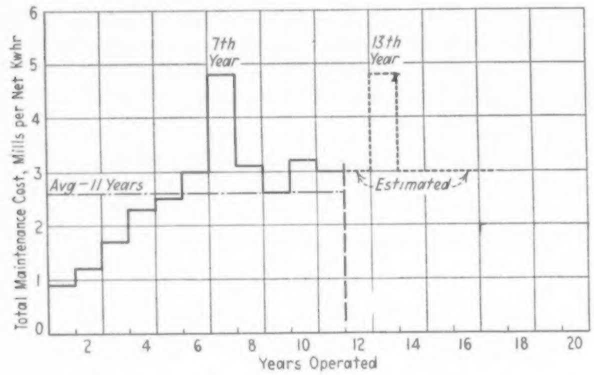

FIG. 7 DIESEL-PLANT MAINTENANCE COST BY YEARS FOR DIESEL GENERATING STATION

(Three units of 500 kw each operated on Diesel fuel at 35 per cent load factor.)

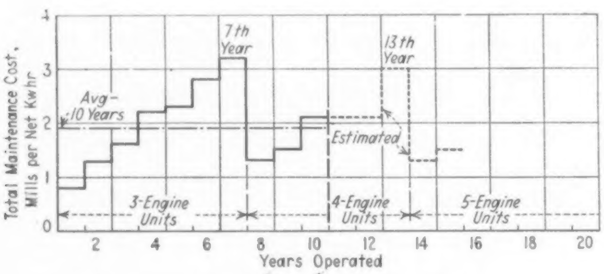

FIG. 8 DIESEL-PLANT MAINTENANCE COST BY YEARS

(Plant started with three 500-kw units; fourth added in seventh year. Operated with Diesel fuel.)

Fig. 7 shows actual maintenance costs for an isolated Diesel generating station containing three 500-kw units operating on good Diesel fuel at approximately 35 per cent station load factor (referred to maximum hour) with no change in capacity installed. Average maintenance cost for eleven years' operation was 2.6 mills per net kwhr. This curve is typical of municipal or utility plants serving small towns where load growth is slight and initial capacity was sufficient for the entire period covered. Curve in Fig. 7 has the same characteristic shape as that in Fig. 5; values shown after eleventh year of operation are estimated only.

Maintenance costs shown in Fig. 8 are for a Diesel generating station with three 500-kw units initially and for a fourth added in the seventh year of operation. A good grade of Diesel fuel was also used. This maintenance curve is typical for municipal or utility plants where load increases to such an extent that a new unit is required after several years' operation. It shows that peak maintenance in the seventh year was much less than that in Fig. 7, and average maintenance cost for 10 years was 1.9 mills per net kwhr. The reduction was due to operation of the new engine as a base-load unit, placing the older units in the station on more or less reserve and peaking service. The low maintenance cost in the eighth year is attributable entirely to operation of the new unit, and the curve shows how this maintenance gradually increased again up to the tenth year, or end of period for which actual data were available. Estimated maintenance cost after the tenth year, shown by dotted line, indicates probable increase until the thirteenth year, at which time another new unit might be added, if load should increase to demand more capacity. With a second new unit, maintenance cost would again be reduced for succeeding years.

The purpose of the curves in Figs. 5 to 8, inclusive, as already stated, is to show that peak maintenance years can be expected at certain periods. Additional data from many other plants could be presented, but the author believes the curves shown are representative for almost all continuously operated plants. The frequency of maintenance peaks will, of course, depend on kind of plant and operating conditions. Likewise, the magnitude of yearly maintenance costs and unit costs in mills per kilowatthour may be different under other conditions and there is no desire in this paper to fix maintenance-cost values.

DIESEL-PLANT OUTAGE DATA

Meager data have heretofore been available with respect to operating factors or outages for Diesel-engine units. The information given in Tables 1 to 4 has been summarized from special surveys made during the past three years, of a group of Diesel generating stations in utility, municipal, and industrial service. The original data were collected for Subcommittee on Oil and Gas Engines, Prime Movers Committee, Edison Electric Institute and were incorporated in subcommittee reports

TABLE 1 SUMMARY OF DIESEL-PLANT LOAD, LABOR, AND MAINTENANCE DATA

	1933	1934	1935	3-year average
Plants reviewed......	20	25	25	23
Units installed.......	52	76	75	68
Average units per plant..............	2.6	3	3	3
Average rated capacity per plant, bhp.	1,388	2,184	2,370	1,981
Averaged rated capacity per plant, kw..	950	1,500	1,640	1,363
Average net output per plant, kwhr....	1,886,038	3,164,290	4,212,710	3,087,680
Average auxiliary uses, per cent.......	4.9	5.7	5.9	5.5
Average maximum hour, kwhr........	700	989	1298	996
Average annual load factor, per cent.....	36.9	38.0	35.8	36.9
Average labor per plant, man-hr......	11,865	14,348	14,283	13,499
Average cost material for engine maint., dollars............	1,358	2,516	4,171	2,682
Average heat rate per net kwhr output, Btu	17,514	15,684	15,168	16,122
Details on plant labor				
Plants reporting....	12	16	16	15
Operating labor per plant, man-hr....	8,301	12,985	12,923	11,403
Maintenance labor-regular, man-hr..	1,501	1,196	2,940	1,879
Maintenance labor-extra, man-hr....	428	481	481	463
Total labor per plant, man-hr....	10,230	14,662	16,344	13,745

of 1934, 1935, and 1936. Plants reporting data are all well supervised and are believed to represent better-than-average operating conditions.

Table 1 gives a summary by years, of the load, labor, and maintenance data collected on all plants submitting reports. The three-year average shows that the 23 plants reviewed each had an average of three units installed; the average rated capacity per plant was 1981 bhp or 1363 kw. The average annual station load factor was 36.9 per cent. Average labor per plant per year was 13,499 man-hours, and average cost of *material* for engine maintenance was $2682, equal to $1.35 per engine bhp-year. The distribution of total labor reported by 15 of the plants showed that operating labor was about 83 per cent of total plant labor, regular maintenance labor 13.6 per cent, and extra maintenance labor 3.4 per cent. If labor for maintenance is taken at the percentage shown (17 per cent of total labor in man-hours per plant per year) and 75 cents is assumed as a fair rate per man-hour, then maintenance labor amounts to $1720 per year and total engine maintenance cost becomes $2.20 per engine bhp-year; and a small amount should be added for maintenance of other equipment in order to arrive at a figure for total plant maintenance. This maintenance cost applies only to plants with station load factor as low as 36.9 per cent.

TABLE 2 SUMMARY OF OPERATING RECORD FOR DIESEL UNITS FOR PLANTS REPORTING OUTAGE DATA

	1933	1934	1935	3-year total	Avg per unit	Per cent of period hours
Number of Diesel units reported..	30	40	43	113	1	...
Rated capacity of units reported:						
Bhp........................	13,950	30,785	39,100	83,835	742	...
Kw.........................	9,716	21,246	27,586	58,548	518	...
Kilowatt-hours generated.........	17,518,575	43,065,989	87,233,140	147,817,704	1,308,000	...
Period hours....................	262,800	350,400	376,563	989,763	8,759	100.0
Demand hours....................	109,567	155,147	180,783	445,497	3,940	45.0
Service hours....................	103,525	143,148	159,877	406,550	3,597	41.1
Idle hours......................	159,275	207,252	216,686	583,213	5,162	58.9
Reserve hours....................	151,717	190,125	194,518	536,360	4,745	54.2
Outage hours, total.............	7,567	17,127	18,795[a]	43,489	385	4.4
Engines......................	4,758	10,079	14,028	28,865	256	2.9
Generators....................	72	574	377	1,023	9	0.1
Auxiliaries....................	427	540	76	1,043	9	0.1
Other causes..................	2,310	5,934	4,314	12,558	111	1.3
						3-year average
Operating factors, per cent						
Service demand................	41.7	44.2	47.9	.....	...	44.6
Service-demand availability.....	94.5	92.2	88.4	.....	...	91.7
Unit capacity.................	20.6	23.1	36.1	.....	...	26.6
Unit output...................	52.2	56.5	85.0	.....	...	64.8
Unit operation................	39.4	40.9	42.5	.....	...	40.9
Maximum possible unit operation........................	97.1	95.2	94.1	.....	...	95.5

[a] Outage of 3373 hours for rebuilding engine foundation at one plant not included in outage hours.

Detailed operating history and outage data were submitted on about 40 Diesel units, of the 68 total reported. The engine for which these detail data were reported averaged 742 bhp (518 kw). A summary of period hours, demand hours, service hours, idle hours, reserve hours, and outage hours for all units appears in Table 2. It is shown that the demand hours were only 45 per cent of period hours, service hours 41.1 per cent, idle hours 58.9 per cent, reserve hours 54.2 per cent, and outage hours 4.4 per cent. The high idle-hour factor indicates that light-load conditions prevailed and that units were inactive in many of the stations. Low outage factor (4 per cent of period hours), is explained by the fact that certain engines were operated very little.

Table 2 also gives detailed analysis of outage hours. Average outages per unit were 385 hr, divided as follows: Due to engines 256 hr, to generators 9 hr; to auxiliaries 9 hr; and to other causes 111 hr. These figures show that the total outage per engine consumed 385 hr out of the 3940 average demand hours per engine, i.e., that outages were 9.4 per cent of the demand hours. This value again may be somewhat low on account of low use factor of engine units.

Table 2 furthermore shows operating factors, in per cent, for service demand, service-demand availability, unit capacity, unit operation, and maximum possible unit operation. No doubt the most valuable factor in this table is that for service-demand availability, which is 91.7 per cent. This service-demand availability factor would have been lower if either service-demand or unit-output factor had been higher; these factors average less than 45 per cent. Definitions for terms used in this and related tabulations are as follows:

TABLE 3 AVERAGE OUTAGE FACTORS

	1933	1934	1935	3-Year total	Per cent of total
Number Diesel units reported.................	30	40	43	113	...
Outage hours, total					
Engines................	4,758	10,079	14,028	28,865	66.4
Generators.............	72	574	377	1,023	2.3
Auxiliaries.............	427	540	76	1,043	2.4
Miscellaneous..........	34	9	42	85	0.2
Inspections.............	2,276	5,925	4,272	12,473	28.7
Total................	7,567	17,127	18,795	43,489	100.0
Outages, per cent of					
Period hours...........	2.9	4.9	5.0	12.8	4.3
Demand hours	6.9	11.0	10.4	28.3	9.4
Service hours...........	7.3	12.0	11.7	31.0	10.3

Outage hours = total time during which unit is not ready for service
Period hours = total hours per year in the case of units more than one year in service; in case of new units, from hour of initial operation to end of the year
Demand hours = total time unit is required for service
Service-demand factor = ratio of demand hours to period hours
Service-demand-availability factor = ratio of service hours to demand hours
Unit-capacity factor = ratio of kilowatthours generated to product of unit rating and period hours
Unit-output factor = ratio of kilowatthours generated to product of unit rating and service hours
Unit-operation factor = ratio of service hours to period hours
Maximum possible unit-operation factor = ratio of sum of service hours and reserve hours to period hours
Outage factor = ratio of outage hours to period hours
Reserve factor = ratio of reserve hours to period hours.

Table 3 shows average outage factors, in per cent of total outages. Outages resulting from engine troubles account for

TABLE 4 ANALYSIS OF DIESEL-PLANT OUTAGE HOURS

	Outage hours 1933	1934	1935	3-year total	Per cent of total	Number machines affected	Outage hours per machine affected
Number Diesel units reported	30	40	43	....	...	..	...
Engines							
Crankshaft	97	336	4,104	4,537	11.0	5	907
Main pistons and piston rings	1,209	1,216	1,748	4,173	10.1	71	59
Cylinder liners	55	1,796	879	2,730	6.6	14	195
Crank and piston-ring bearings	361	805	1,317	2,483	6.0	52	48
Air compressors (air-inj. engines)	475	672	1,069	2,216	5.4	31	71
Governors and governor drives	184	1,033	72	1,289	3.1	25	52
Cylinder heads	135	123	955	1,213	2.9	32	38
Fuel-spray valves (try valves, etc.)	410	348	249	1,007	2.4	43	23
Exhaust valves (four-cycle eng.)	310	305	354	969	2.3	35	28
Cracked frames and cylinders	0	0	962	962	2.3	6	160
Main bearings (incl. thrust and outboard)	92	147	685	924	2.2	29	32
Fuel-oil system	60	669	121	850	2.1	22	39
Water cooling (incl. scale trouble)	112	236	496	844	2.0	35	24
Air-inlet valves	145	442	171	758	1.8	35	22
Fuel pumps, distributors, drives, etc.	137	216	240	593	1.5	51	12
Scavenging pump (two-cycle eng.)	525	4	40	569	1.5	7	81
Crosshead pins and bearings	292	267	0	559	1.4	5	112
Connecting-rod bolt failures	0	550	4	554	1.3	4	139
Lubricating-oil system	61	203	272	536	1.3	37	15
Piston cooling	31	166	59	256	0.6	18	14
Exhaust ports, chambers, etc	13	160	28	201	0.5	17	12
Starting trouble (incl. explosions)	8	161	17	186	0.4	11	17
Valve setting, timing, etc	8	6	28	42	0.1	6	7
Adjusting compression	17	0	8	25	0.1	5	5
Camshaft and bearings	0	11	0	11	0.0	4	3
Vertical shaft and bearings	0	0	0	0	0.0	0	0
Gears and chain drives	0	0	0	0	0.0	0	0
Vibration	0	0	0	0	0.0	0	0
Miscellaneous	21	207	150	378	0.9	22	17
Inspection and adjustment	2,276	5,925	4,272	12,473	30.2	58	215
Total	7,034	16,004	18,300	41,338	100.0	..	...
Generator							
Field windings	0	424	7	431	42.1	5	86
Armature windings	38	37	105	180	17.6	11	16
Vibration	0	0	144	144	14.1	1	144
Exciter	14	72	43	129	12.6	19	7
Collector rings	0	0	34	34	3.3	1	34
Alignment	3	0	9	12	1.2	2	6
Bearings	0	0	10	10	1.0	1	10
Armature core	10	0	0	10	1.0	1	10
Lubrication	0	1	0	1	0.0	1	1
Miscellaneous	3	40	25	68	6.7	12	6
Inspection and adjustment	4	0	0	4	0.4	1	4
Total	72	574	377	1,023	100.0	..	...
Auxiliary equipment							
Exhaust system	57	254	32	343	32.9	6	57
Water-cooling system	218	7	13	238	22.8	8	30
Lubricating equipment	43	136	0	179	17.2	8	22
Air compressors	0	94	10	104	10.0	4	26
Fuel-oil equipment	21	27	0	48	4.6	7	7
Air-intake system	0	4	20	24	2.3	2	12
Water pumps	0	18	0	18	1.7	1	18
Air receivers	1	0	1	2	0.2	2	1
Automatic-control equip	0	0	0	0	0.0	0	0
Miscellaneous	87	0	0	87	8.3	2	44
Inspection and adjustment	0	0	0	0	0.0	0	0
Total	427	540	76	1,043	100.0	..	...
Other causes							
Piping	17	0	23	40	47.1	7	6
Plant electrical	15	1	19	35	41.1	12	3
Outside electrical	0	6	0	6	7.1	1	6
Miscellaneous	2	2	0	4	4.7	2	2
Total	34	9	42	85	100.0	..	...

66.4 per cent of total outages; outages for generators 2.3 per cent; for auxiliaries 2.4 per cent; miscellaneous and unclassified 0.2 per cent; inspection 28.7 per cent. These figures are believed to be representative and require no particular comment. Table 3 also shows total outages for all engine units were 4.3 per cent of period hours, 9.4 per cent of demand hours, and 10.3 per cent of service hours.

A particularly useful section of data from this three-year survey of Diesel generating units is contained in the analysis of Diesel outage hours, Table 4. The main tabular figures do not separate outages for two-cycle and four-cycle engines, and for this reason outage percentages shown for exhaust-valve troubles (which apply only to four-cycle engines), as well as outages for scavenging pumps (applying only to two-cycle engines), and for air-injection engines are lower than would otherwise be expected. Segregation of outages according to type of engine would modify some of the data, but this was not considered advisable for the present analysis. It is felt that data presented in Table 4 will be valuable to engine manufacturers, because the seriousness of certain kinds of engine failures is definitely emphasized.

Table 4 shows that principal outages for engines, aside from those for inspection and adjustment which require about 30 per cent of the outage time, were caused by the following: Crankshaft troubles which require 11 per cent of total outage time and occurred on only five machines of the total number reported consumed 907 outage hours per machine; main-piston and piston-ring outage required 10.1 per cent of total outage time; cylinder liners 6.6 per cent; crank and piston-pin bearings 6 per cent; air compressors 5.4 per cent; governors and governor drives 3.1 per cent; cylinder heads 2.9 per cent. In addition to the percentage of time lost by various causes for outages, it is interesting to note the actual outage hours per machine

(*Continued on page 102*)

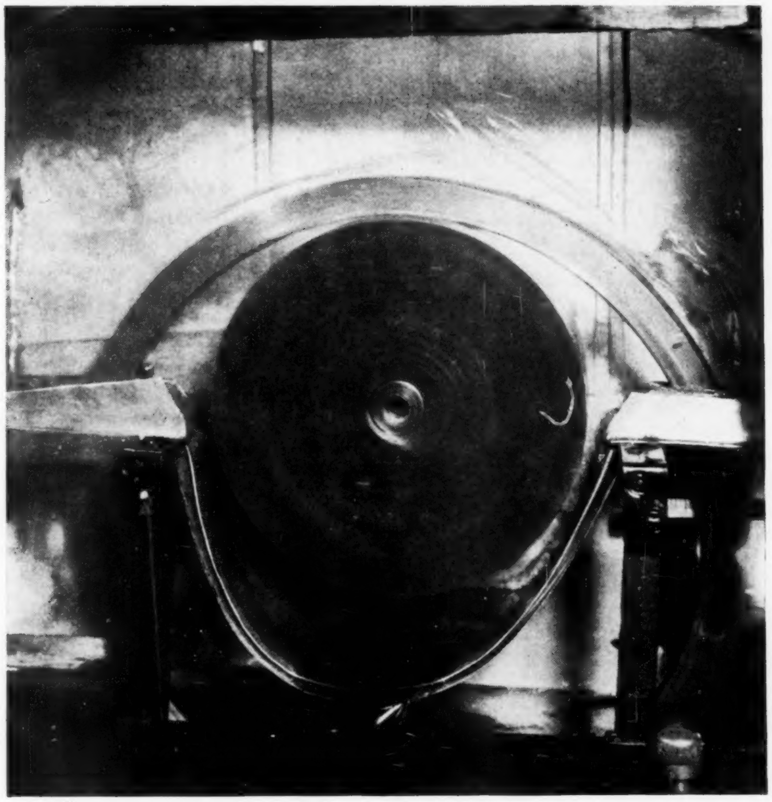

FIG. 1 JOURNAL AND OIL RING OF EXPERIMENTAL APPARATUS

PERFORMANCE *of* OIL RINGS

Results of Tests on Various Special Types of Rings

By R. BAUDRY and L. M. TICHVINSKY

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THE OIL-ring-lubricated bearing is probably more widely used than any other. Its simplicity and ruggedness make it a safe and economical bearing, and it requires little maintenance and attention. On account of these desirable qualities manufacturers have always attempted to extend its application.

Several years ago a series of tests[1] was made for the purpose of studying the conditions of operation of oil rings. At that time it was found that the best results were obtained with a brass ring of trapezoidal cross section.

Recently, additional tests were made on new types of oil rings in an attempt to increase further the quantity of oil delivered to the bearing.

The testing machine was designed to duplicate as closely as possible the normal conditions of operation of an oil ring in a bearing.

As seen in Fig. 1, the journal is a polished steel disk mounted on the shaft of a variable-speed motor. The oil ring runs through two guides located on each side of the journal near its horizontal center line. These guides, which are normally part of the lower bearing shell, also act as oil catchers. The clearance between them and the oil rings is kept to a minimum in order to catch the maximum amount of oil. This oil, which is normally fed to the lower bearing shell, is collected in a scoop and measured. The complete assembly is placed in a box, the bottom of which serves as an oil reservoir in which the lower part of the oil ring is submerged. The front of the box is covered with celluloid sheets, which facilitate careful observation of the conditions to which the ring is subjected in regular operation.

All tests were made with full-size models. Electric heaters were placed at the bottom of the reservoir to keep the oil at any desired temperature. All tests were made with an oil having a viscosity of 200 sec Saybolt at 100 F and 46 sec at 212 F.

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[1] "Performance of Oil-Ring Bearings," by G. B. Karelitz, Trans. A.S.M.E., vol. 52, 1930, paper APM-52-5.

Contributed by the Subcommittee on Lubrication Engineering of the Machine Shop Practice Division and presented at the Annual Meeting, Nov. 30 to Dec. 4, 1936, of The American Society of Mechanical Engineers.

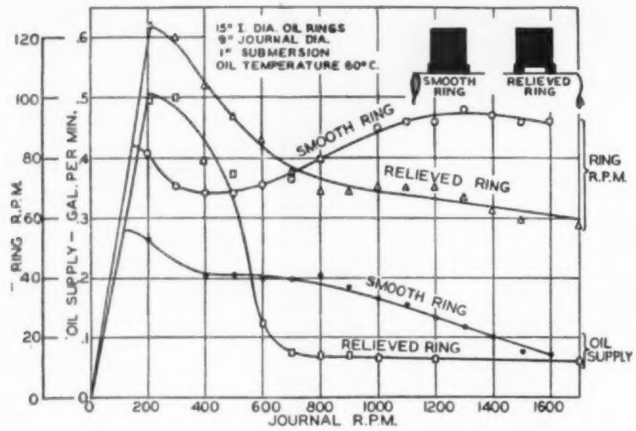


FIG. 2 OIL-RING PERFORMANCE

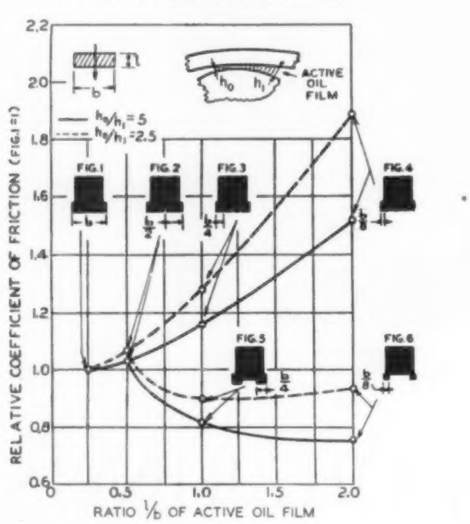


FIG. 3 VARIATION OF COEFFICIENT OF FRICTION WITH DIFFERENT TYPES OF GROOVING

TEST RESULTS

In the course of a series of tests on different types of oil rings some interesting results were obtained, as shown in Fig. 2. These tests were performed on two rings that were identical except for the fact that the bore of one was relieved. It is seen that at very low speed both rings follow the journal, this being the region of solid friction. The amount of oil delivered increases with the speed and is the same for both rings. Then the smooth ring begins to slip and its speed and oil delivery drop immediately, this being the region of semifluid friction. The relieved ring follows the shaft a little longer and then it too begins to slip. In that region the speed and oil delivery of the relieved ring are greater than those of the smooth ring. With increasing journal speed the oil delivery of both rings continues to decrease, but more rapidly for the relieved ring than for smooth ring, this is the region of fluid friction, in which the smooth ring delivers more oil than the relieved ring.

This performance can be explained by considering that the oil ring on the journal is acting like a journal bearing with large clearance. For this case the coefficient of friction f in the region of fluid friction is given by the formula[2]

$$f = K_L K \sqrt{ZV/W}$$

where

K_L = the leakage factor, depending on the ratio between the length of the active oil film and the width of the oil ring

K = a coefficient depending upon difference in radii between the oil ring and the shaft

Z = the absolute viscosity of oil

V = the relative velocity between the oil ring and the journal

W = the load per unit width of the oil ring.

From this formula it is seen that by relieving the center of the ring the load W per unit width is increased, and thus a smaller

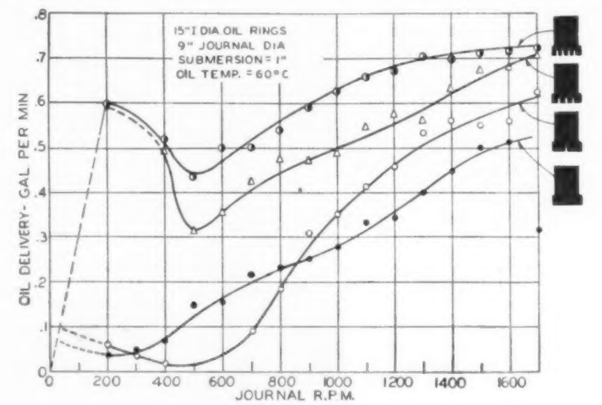


FIG. 4 AMOUNT OF OIL DELIVERED BY RINGS WITH DIFFERENT NUMBERS OF GROOVES

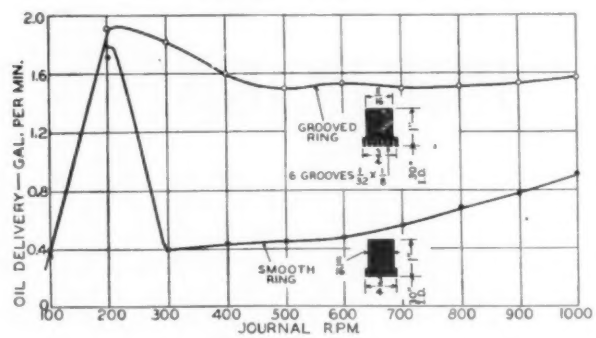


FIG. 5 AMOUNT OF OIL DELIVERED BY SMOOTH AND GROOVED RINGS AT VARIOUS JOURNAL SPEEDS

(Oil temperature = 60 C; submersion = 3 in.; viscosity = 15 centipoises.)

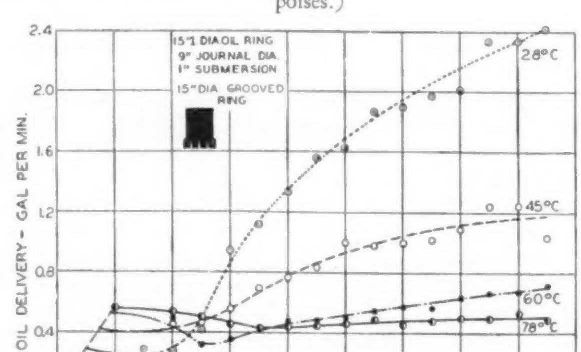


FIG. 6 AMOUNT OF OIL DELIVERED AT VARIOUS TEMPERATURES

[2] "Journal Bearing Performance," by R. Baudry and L. M. Tichvinsky, *Journal of Applied Mechanics*, Trans. A.S.M.E., vol. 57, 1935, p. A-121.

value of the coefficient of friction is obtained. This explains the lower speed of the relieved oil ring. A larger value of the coefficient of friction can be obtained by increasing the side-leakage factor K_L. This can readily be made by cutting small grooves on the inner bore of the ring. These narrow grooves increase only slightly the load W per unit width, which is thus kept to a minimum.

In Fig. 3 the effect of the grooves and relief has been plotted for an arbitrarily chosen shape of oil film. It is seen that the coefficient of friction is decreased by the relief and increases rapidly with the number of grooves.

In order to verify experimentally the effect of the grooves, four new rings were made, absolutely identical except for the inside bore, which was machined as shown in Fig. 4—smooth and with one, three, and five grooves. It is seen in the same figure that the amount of oil delivered increases rapidly with

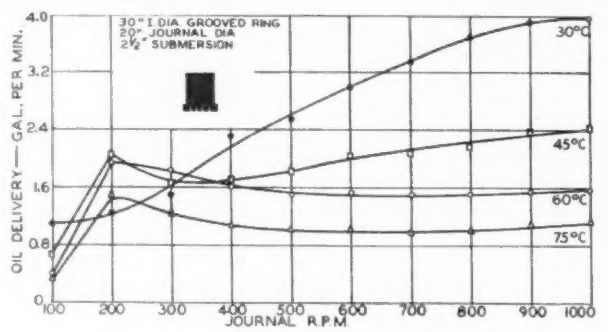


FIG. 7 AMOUNT OF OIL DELIVERED AT VARIOUS TEMPERATURES AND JOURNAL SPEEDS

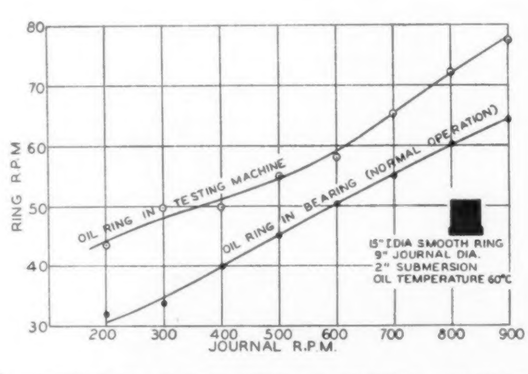


FIG. 8 COMPARISON OF RING SPEED ON BEARING AND ON TESTING MACHINE

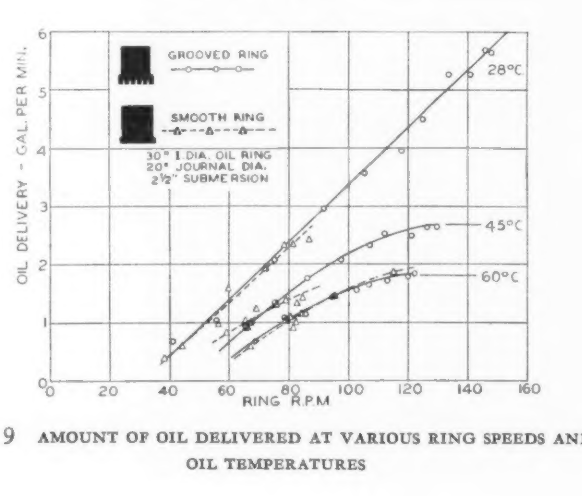


FIG. 9 AMOUNT OF OIL DELIVERED AT VARIOUS RING SPEEDS AND OIL TEMPERATURES

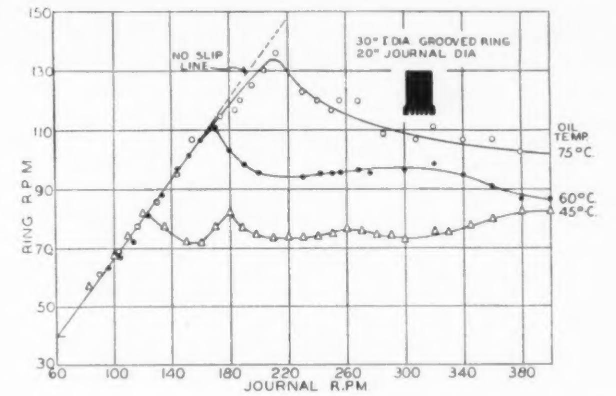


FIG. 10 OIL-RING SPEED AT LOW JOURNAL SPEED AND VARIOUS OIL TEMPERATURES

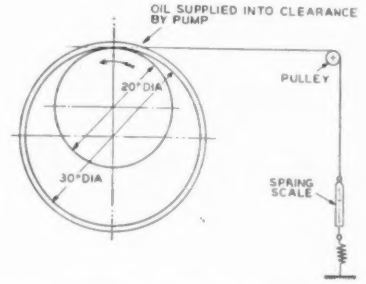


FIG. 11 SETUP TO MEASURE FRICTION BETWEEN OIL RING AND JOURNAL

the number of grooves. Similar results were obtained on a larger ring (Fig. 5) which is now in operation in a machine.

In the tests previously made it was also observed that the accuracy of machining of the rings had a large influence, particularly in the region of semi-fluid friction, where a slight misalignment of the split, for example, could produce rather erratic results.

The amount of oil delivered by the ring decreases rapidly with an increase in temperature of the oil as shown in Figs. 6 and 7. This explains the critical influence of temperature on an oil-ring-lubricated bearing which usually fails without much warning. If the losses and the corresponding temperatures of the bearing increase, the oil supply decreases. If it becomes less than the amount necessary to maintain a normal oil film, the friction increases still more rapidly and an immediate failure of the bearing follows. The decrease in oil delivery with high bearing temperature will probably be larger than indicated in the tests. In normal conditions of operation the oil film on the shaft is warmer than the oil at the lower part of the ring in the reservoir; thus, a lower speed of the ring is obtained as shown in Fig. 8 where the speeds of the smooth ring are plotted when running on the testing machine and on an actual bearing.

In Fig. 9 it is seen that at the same oil temperature and oil-ring speed, the same amount of oil is delivered by the smooth and the grooved rings. This shows that the improved performance of the grooved ring is due to its higher speed for the same journal speed. It can also be seen from Fig. 9 that with high oil temperature the amount of oil delivered rapidly approaches a maximum value at high speed. This is due to the reduced adhesion force of the oil which is thrown off the ring by centrifugal force before it reaches the oil catcher.

Fig. 10 shows the performance of the grooved ring in the regions of solid and semi-fluid friction.

In order to determine the increase in friction produced by

grooving the oil ring a simple setup shown in Fig. 11 has been made, on which the friction between the ring and the journal can be measured directly. Rotation of the ring is prevented by means of a horizontal string tied at one end to the ring in such a way that its line of action is tangent to the journal at the point of contact with the ring; the other end of the string is connected to a spring scale. To simulate actual conditions an amount of oil sufficient to maintain the oil film between the ring and the journal is supplied by means of a pump connected to the oil reservoir. The variation of the values of the coefficient of friction with various speeds and viscosities is shown in Figs. 12 and 13. It is interesting to note that the measured coefficients of friction are of the same order as the theoretical ones for an infinitely wide smooth ring. An average increase of 65 per cent in friction obtained by grooving the ring agrees rather well with the relative coefficient of friction given in Fig. 3.

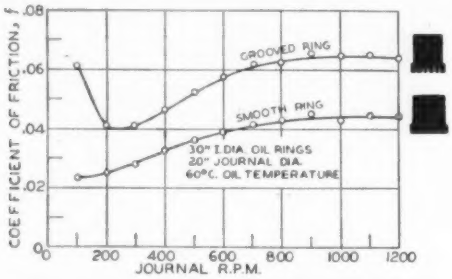


FIG. 12 MEASURED COEFFICIENT OF FRICTION FOR SMOOTH AND GROOVED RINGS AT VARIOUS SPEEDS

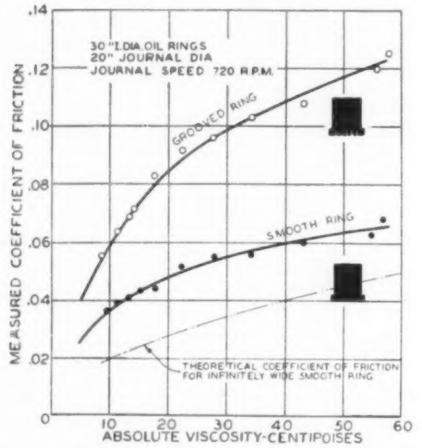


FIG. 13 MEASURED COEFFICIENT OF FRICTION FOR SMOOTH AND GROOVED RINGS AT VARIOUS VISCOSITIES
(Oil: 200 sec S. at 100 F; 46 sec S. at 212 F.)

CONCLUSION

The size and number of oil rings now used on journal bearings are usually determined by experience or cut-and-try methods. In order to predetermine the operating characteristic of an oil ring, further data such as the resisting skin friction of the lower part of the oil ring and the work done to lift the oil are necessary. Tests concerning these factors are being made and will be the subject of another paper.

It is hoped that sometime it will be possible to predetermine the performance of oil rings by applying the hydrodynamical theory of lubrication.

In the case of a bearing the designer's aim is to decrease the friction while in the case of an oil ring the opposite is attempted.

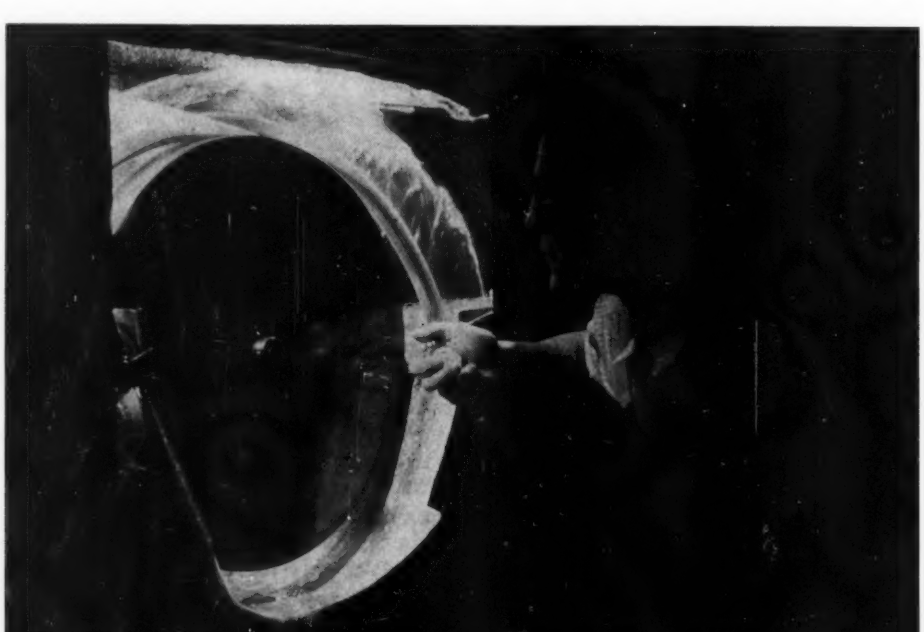
The grooved oil ring acts like a grooved tire on a wet, smooth road, where the friction is much higher than it would be if the tire were old and smooth.

The grooved oil ring has already been applied with success to high-speed rotating machinery where lower operating temperatures or larger factors of safety were obtained.

ACKNOWLEDGMENT

Acknowledgment is due to M. W. Smith, manager of engineering, and R. E. Peterson, manager, mechanics division, research laboratories of the Westinghouse Electric and Manufacturing Company, who made these investigations possible.

The authors are also indebted to H. C. Westin and J. J. Gianino who assisted during tests.



HEAT BALANCE *Versus* WEIGHED BOILER TESTS

By E. L. McDONALD and R. WINTERS

KANSAS CITY POWER AND LIGHT COMPANY, KANSAS CITY, MO.

GRADUAL growth in the size of the modern steam-generating unit has increased the expense, complications, and hazards in the "water-coal-weighed" method of testing to such an extent that it has forced greater use of the heat-balance method. The source and magnitude of errors in both methods, based on actual test results, together with their effect on the unit efficiency, form the basis for this paper.

In past years the boiler heat balance was regarded only as a check on an actual evaporation test. If the unaccounted-for loss, as determined by the heat balance, and the water-coal-weighed efficiency were reasonable, the test was assumed to be correct; if not, something was wrong. However, innumerable boiler tests have been run and efficiencies have been determined without the heat balance.

For certain purposes it is permissible to run a boiler test without computing a heat balance; but for reliable results a heat balance is essential. Obviously, two checks are better than one. However, because the increasing size of steam-generating units is forcing us to the heat-balance method of testing whether we like it or not, we may as well accept the fact and proceed to find out what can be expected from this method.

There are those persons who are already so convinced of its merit that if given the choice of a water-coal-weighed test or a heat-balance test they would select the latter as the more desirable. Also, the accuracy of testing is probably influenced more by personnel than by method. One inexperienced in testing would not expect accuracy by either method. Those who favor the heat balance reason that if an evaporative test efficiency is really acceptable only when the unaccounted-for loss in the heat balance is "reasonable," then why isn't it possible to use a heat-balance efficiency if the various losses are justified by existing test conditions and a "reasonable" unaccounted-for loss is assumed? After all, the use of a single boiler test to determine unit performance is a rather unreliable procedure. A series of tests at various ratings is, of course, far more acceptable and reliable; and whether the results be determined by heat balance or evaporation, if one particular test falls "out of line," the point is given little weight.

COAL SAMPLING

It is a simple matter to calculate the theoretical loss for a definite variation in CO_2 or a definite variation in stack temperature. It is equally simple to calculate the difference in efficiency for any definite variation in calorific value of the fuel, but it is quite another thing to know what these variations might normally be in actual practice, where to look for them, and how to hold them to a minimum. Such information can be obtained only from actual tests and then only when special effort has been made in preparation for, and during, the test to determine the possibility and extent of these errors. For example, the test engineer who has just one heat value determination made on the fuel by just one chemist rests in ignorance of the many efficiencies he might have obtained on this single test if several chemists had analyzed separate samples of the fuel, particularly if it is of the solid type. This is not necessarily a reflection on the chemist, as wide discrepancies may result from poor sampling.

As this particular phase of boiler testing represents the greatest potential source of error, it will bear elaboration. Too much stress cannot be placed on accurate fuel sampling. For example, separate coal samples taken by two individuals from various sections of cars as they were being unloaded in some instances differed as much as 700 to 800 Btu on 10,000-Btu coal, or a variation of from 5 to 6 per cent in efficiency for tests based on such sampling. Samples taken from a coal-conveyor belt by an automatic sampler varied as much as 400 Btu from samples obtained by periodically stopping the belt and sampling complete sections of coal from points comparable with the automatic sampler. Inasmuch as the discrepancies were both plus and minus, the average of several cars could be considered to be about right. A number of checks on duplicate samples of coal, quartered and crushed to pass through a $^1/_4$-in. round screen, showed a maximum difference of 333 Btu and an average difference of 138 Btu in 10,500-Btu coal. Such variations may not be normal with coals of consistent quality, but such are the results with Mid-West strip-pit coals.

LABORATORY

While it is conceded that on a 60-mesh sample two reliable chemists can check each other within 50 or 75 Btu, unfortunately, however, as with any other profession, all chemists are not reliable, nor is all laboratory equipment up to standard. In either case, the effect is the same—inconsistent results. An actual example from the many available will make evident the possible error from this source.

To settle a controversy with a mine operator, duplicate 60-mesh coal samples were sent to two commercial laboratories and one central-station laboratory. The central-station and one commercial laboratory checked within 70 Btu, 0.32 per cent of ash, and 0.21 per cent sulphur. The second commercial laboratory, which advertised 40 years of experience in the analysis of coal, reported a heating value 1393 Btu lower and a sulphur content 3.95 per cent lower than the average reported by the other two laboratories. When the remainder of its 60-mesh sample was analyzed by a fourth laboratory, the results of the first two laboratories were verified.

This example is not quoted as a reflection on all laboratories, as the majority are undoubtedly reliable, but it will serve to show the possible errors that can exist and that the error at times exceeds the 50 to 75 Btu commonly recognized as the laboratory error.

Contributed by the Fuels Division and presented at the Semi-Annual Meeting, Dallas, Texas, June 15 to 20, 1936, of The American Society of Mechanical Engineers.

EFFECT ON EFFICIENCY

Many probably have the impression that such discrepancies as described would affect the heat-balance efficiency in the same magnitude as they would the actual evaporation-test efficiency, but this is not correct. It is conceded that the number of possible errors is greatest in the heat-balance method, but the combined magnitude of these errors may be less than a single possible error in the evaporative-test method (that of coal sampling or heating-value determination as already shown).

The effect of discrepancies in analyses is best illustrated by an example using the actual results obtained on one of a series of tests in which water, coal, and ash were weighed and other precautions were taken to assure accurate results. The first column of Table 1 shows the analysis accepted as correct because notes throughout the test indicated that conditions were normal and both the efficiency, as determined by actual water and coal weights, and the unaccounted-for losses, as determined by difference, fell in line with adjacent tests. If 3.7 per cent were a reasonable radiation and unaccounted-for loss (and it is for the particular unit tested, which included two economizers in addition to the boiler), then the efficiency as determined by the heat-balance method would, of course, be the same as that determined by the water-coal-weighed method, as shown at the bottom of the first column of this table. Column 2 shows the effect of an incorrect coal sample wherein a higher heating value than representative of the average was obtained. The heat value calculated from the ultimate analysis by DuLong's formula checks that shown, hence, the two are in the proper relation. The effect of this error in coal sampling is shown in the heat-balance calculation at the bottom of the column, wherein the efficiency as shown by the heat-balance method checks within 1.0 per cent of the true efficiency (as shown in column 1) and the efficiency by the water-coal-weighed method differs by 3.2 per cent from the true efficiency. This shows that poor sampling has a greater effect on the water-coal-weighed efficiency than on that determined by the heat-balance method.

TABLE 1 EFFECT OF INCORRECT SAMPLING ON EFFICIENCY

Condition no.	1	2	3
	Actual	Incorrect sample	Incorrect ultimate analysis
Coal, ultimate analysis "dry:"			
Carbon, per cent	65.5	68.69	60.00
Hydrogen, per cent	4.24	4.17	6.00
Oxygen, per cent	6.59	5.60	10.40
Nitrogen, per cent	1.21	1.25	0.40
Sulphur, per cent	3.74	3.68	4.50
Ash, per cent	18.72	16.63	18.70
Heating value, dry, Btu per lb.	11,830	12,330	11,830
Moisture, "as fired," per cent	12.00	12.00	12.00
Ash in refuse, per cent	80	80	80
Analysis of stack gases:			
CO_2, per cent	13	13	13
CO, per cent	0	0	0
O_2, per cent	7	7	7
N_2, per cent	80	80	80
Temperature of gas to stack, F.	350	350	350
Temperature of room air for combustion, F.	70	70	70
Temperature of room air, wet bulb, F.	60	60	60
Carbon burned per pound of coal, "dry," lb.	0.6082	0.6453	0.5532
Heat balance:			
Loss due to dry chimney gases, per cent	6.9	7.1	6.3
Loss due to moisture in coal, per cent	1.4	1.3	1.4
Loss due to water from combustion of hydrogen, per cent	3.8	3.6	5.4
Loss due to moisture in air, per cent	0.1	0.1	0.1
Loss due to unconsumed combustible in refuse to ashpits, per cent	5.6	4.7	5.6
Loss due to unconsumed combustible in refuse blown through boiler, per cent	0.2	0.2	0.2
Loss due to radiation and unaccounted-for, per cent	3.7	7.9	2.7
Efficiency by water-coal-weighed test, per cent	78.3	75.1	78.3
Error by water-coal-weighed test, per cent	0.0	3.2	0.0
Efficiency by heat-balance test, per cent (based on 3.7 per cent radiation and unaccounted-for)	78.3	79.3	77.3
Error by heat-balance test, per cent	0.0	1.0	1.0

In column 3 is set up as an example an ultimate analysis that will check the correct heating value, but, from a knowledge of the coal, is obviously incorrect. If this analysis were accepted, the effect on efficiency would be an error of 1 per cent in the heat balance for this condition, and this on an analysis that is obviously in error. Hence, any normal error that might exist in the ultimate analysis of a coal sample would make little difference in the efficiency determined by the heat-balance method.

In a similar manner it would be possible to show that an error of 1 per cent in the moisture determination would affect the heat-balance efficiency by only 0.12 per cent, whereas the actual water-coal-weighed efficiency would be affected by 0.80 per cent. Of course the latter would not be subject to the small possible error in figuring the heat loss from this moisture, which should not exceed 0.1 per cent.

COMBUSTIBLE IN ASH

The percentage of combustible lost to the pit and carried out with the stack gases with either stoker or pulverized-coal firing varies over wide ranges. The quantity of ash carried away with the gases in the stoker-fired unit will depend on such factors as rating, coal sizing, dryness, and the character of the fuel. In the burning of Mid-West anthracite on forced-draft chain-grate stokers, 30 per cent combustible in the fly ash, representing 2.5 per cent of the heat in the fuel, is not uncommon, compared with 0.2 to 0.3 per cent as a normal loss in the bituminous coals. Incidentally, this indicates a factor which must be considered when burning fuels of this character and makes it evident that the "fly ash" loss cannot always be neglected, as has been suggested at times.

From the foregoing it is apparent that the possibility of error in determining the combustible losses on a stoker-fired unit lies not only in the sampling of the ash discharged to the pit but also, in the burning of certain coals, of that carried out with the stack gases.

In the firing of pulverized coal the percentage of combustible lost to the pit and stack is a function of rating, type of burner, air distribution, furnace design, mill grind, and character of fuel. In a unit-mill installation firing Mid-West bituminous coal through Lupulco down-shot burners into a hopper type of furnace, from 10 to 20 per cent of the ash was reclaimed from the pit, the remainder being carried out with the stack gases. That which lodged in the passes and hopper was returned to the pit.

Collecting a true representative sample of ash from the flue gases is obviously a greater problem than obtaining a repre-

sentative sample from that deposited in the ashpit. Several papers have been written on methods of collecting such samples and it is not within the scope of this paper to go into mechanical details. Suffice to say that with reasonable care in collecting samples the normal error in determining the combustible loss is not as great as might be expected. Perhaps this is best seen in the curves presented in Fig. 1, based on Mid-West bituminous coal burned in the furnace described. While curve *A* shows a wide variation in percentage of combustible in various sizes of ash particles, curve *B* shows that the proportional part over 200 mesh represents a small percentage of the total sample. In other words if, through velocity effect, 25 per cent of the larger particles (over 200 mesh) were thrown to one side and missed the sampler, the final difference in efficiency due to combustible losses would be only 0.06 per cent. This is again evident from curve *C* which shows the percentage of combustible in the remaining sample with various sizes of ash particles removed. Again, if 25 per cent of the fines below 400 mesh were lost, the ultimate error in the efficiency would be only 0.14 per cent. Thus while the sampling of pulverized-coal fly ash may not be representative, particularly from a standpoint of sizing, the ultimate effect on the heat-balance efficiency is small—at least for the installation and coal described. For some other installation or fuel, similar data would have to be plotted to determine the effect.

Summing up the probable errors in determining the combustible losses, it is probably safe to say that with reasonable

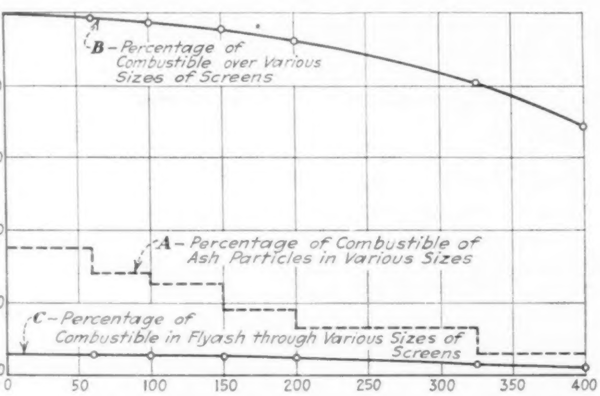


FIG. 1 RELATION OF FLY-ASH SIZE TO PERCENTAGE OF COMBUSTIBLE
(Bituminous coal, Lupulco burner.)

care the error on the pulverized-coal unit should not exceed that just shown. On the stoker-fired unit a survey of 58 tests wherein water, coal, and ash were weighed and analyses were made showed that the maximum error that could be chargeable to combustible losses affected the efficiency as determined by the heat-balance method by 0.6 per cent. It may be well to pause here a moment to emphasize the value of notes which are taken throughout a test. These notes are invaluable later in indicating possible errors either in analysis or calculations. For example, a low percentage of combustible loss would hardly be justified if notes indicated poor fire conditions and heavy losses.

CO_2 AND GAS TEMPERATURE

Of the other variables affecting the heat-balance efficiency, flue-gas analysis and flue-gas temperature are perhaps next in line of importance. The possible error from this source is in proportion to the preliminary effort in establishing representative locations for sampling before actually starting to test a boiler unit. Here again too much emphasis cannot be placed on the suggestion, Don't start testing until these investigations have been made. It is appreciated that this is often a difficult suggestion to carry out, as frequently the fires are hardly lighted in a new installation before a check on the performance of the unit is requested.

Fig. 2 shows a traverse of the air and gas pass of an air

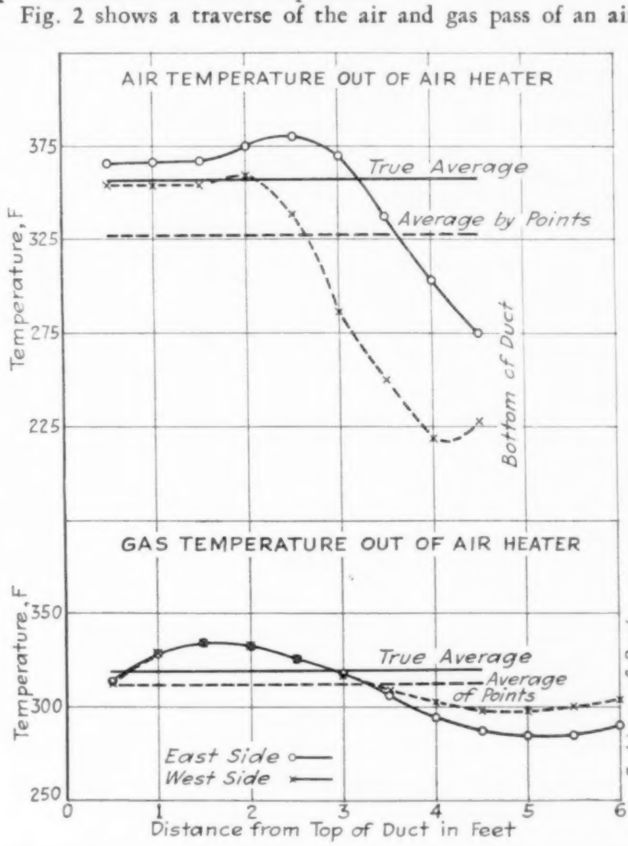


FIG. 2 TRAVERSE OF AIR AND GAS PASS OF AN AIR HEATER ON A PULVERIZED-COAL UNIT OPERATING AT CONSTANT RATING

heater on a pulverized-fuel unit operating at constant rating. A velocity change with rating will frequently cause additional variations and often lead to improper conclusions on a series of tests. The variation shown in air temperature from top to bottom of the air-heater outlet duct is a normal condition on the unit tested. The difference between the "east" and the "west" side is not a normal condition but the result of a dirty gas pass on the west side, however, it represents an actual occurrence and has been plotted to show the temperature difference and error that can exist if the proper data are not obtained. The curve also shows the error that can exist if the straight average of the points is used as the average temperature.

The greatest volume of gas will normally exist in the zone of highest temperature and the true average temperature will be close to the maximum. Such a temperature will check best in the heat balance. Similar data have been plotted for CO_2 samples, and it is only through the collection and analysis of such data that the true performance of any large steam-generating unit can be determined. With these precautions, the maximum apparent error in flue-gas temperature (25 F) on the 58 tests analyzed for this purpose was about 0.6 per cent and for CO_2 (one point difference) an error of about 0.4 per cent in terms of boiler efficiency.

The errors in determining CO or moisture-in-air losses are not considered, as normally these losses are small.

RADIATION

Normally, radiation and unaccounted-for losses are combined, but under certain conditions it may be desirable to separate them. Several methods have been evolved and some good papers have been presented on the calculation of heat losses due to radiation wherein it can be shown that the total heat loss is fairly constant between normal operating ranges, which means that the percentage of loss varies inversely with rating. It is, of course, quite obvious that with the difference in wall construction and gas temperatures existing throughout a modern

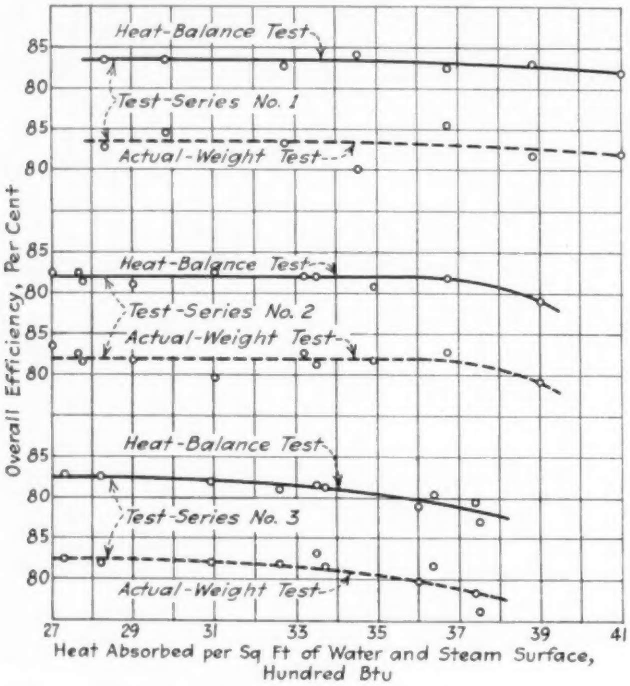


FIG. 3 COMPARISON OF BOILER EFFICIENCIES BY HEAT-BALANCE AND ACTUAL-WEIGHT TESTS

boiler, economizer, and air-heater installation, an elaborate set of temperature-data and calculations would be necessary for real accuracy.

The extent of error in calculating radiation losses is quoted by some authorities as a low figure. In fact, the entire calculated radiation loss frequently appears lower than the actual test results would indicate, and the possibility of error in the calculation is perhaps as great as in any but here again a large error in a figure that does not exceed 1.5 or 2.0 per cent on a modern steam-generating unit will have little effect on the final unit efficiency. For lack of definite information we shall assume 0.5 per cent difference in efficiency due to the possible error in calculating radiation losses.

UNACCOUNTED-FOR LOSSES

In the usual water-coal-weighed heat balance the unaccounted-for loss is, of course, the difference between the heat absorbed plus calculated losses and 100 per cent. It covers the small undetermined losses such as unburned gases, the sensible heat in the ash, moisture in the air (unless figured separately), and such errors as exist in the determination of other losses. If we assume the extreme condition, that is, that all errors are on the plus or minus side and all errors are the maximum shown, then the effect on the heat-balance efficiency is obviously the total of the various figures shown, namely, about 3.2 per cent. If we go to the other extreme and assume these errors just balance, then we have zero error in the boiler efficiency, and herein lies the problem in the heat-balance method of testing: What to do with the errors we know might exist and might be either plus or minus. The answer is best found by the analysis made for this purpose on the water-coal-weighed tests previously referred to, and is briefly this: First, take the necessary precautions to hold errors to a minimum, accept the calculated losses as correct; "assume" a reasonable "radiation and unaccounted-for" loss of 2.0 to 3.5 per cent, depending on the unit construction (on the older stoker-fired unit the figure was 3.7 per cent and on the modern water-cooled pulverized-coal unit, 2.0 per cent); and obtain the efficiency by difference. When this procedure was applied to the seven series containing 58 water-coal-weighed tests previously mentioned, the deviation from the average curve drawn through the water-weighed efficiencies, Fig. 3, was no greater in the heat-balance than in the water-coal-weighed tests.

That this method still offers the possibility of errors is granted, but after all, our final object is to show how these errors compare with those of the water-coal-weighed method of testing, and to do this we must revert to coal sampling and analysis. It will be recalled that a one-point error in the true moisture determination affected the heat-balance efficiency by only 0.12 per cent, whereas the weighed-test efficiency would be in error by 0.8 per cent; and it is not difficult to picture a difference of one per cent between the true moisture and that reported. It will also be recalled from column 2, Table 1, that a difference of 500 Btu due to an improper coal sample or analysis changed the heat-balance efficiency only 1.0 per cent and the water-coal-weighed efficiency 3.2 per cent. While it may be unreasonable to assume that an error of this magnitude would normally exist, it certainly is not unreasonable to assume that between sampling and analyzing an error of 1 to 2 per cent could exist; and if we consider only these two possible errors, namely, moisture and Btu, in the water-coal-weighed test we shall see that their total (2.8 per cent) is almost as great as the combined *maximum* errors in the heat-balance method of testing (3.2 per cent), and certainly as great as any *average* error that might be accepted.

The assumption that calculated losses in the heat-balance method are low, which we make in accepting 2 or 3.5 per cent radiation and unaccounted-for, might be questioned. Justification for this assumption is threefold. First, to consider them as high would make heat absorbed plus losses exceed 100 per cent, which obviously is incorrect. Second, there is a tendency to be low in calculating losses, because it is more likely that moisture will be lost than gained in obtaining a coal sample, the average gas temperature readings are more likele to be low than high, and ash samples can lose heat value. CO_2 determinations are an exception where the tendency is reversed. Third, apply the idea expressed in Fig. 3 to any well-conducted tests and similar results will be obtained.

CONCLUSION

The desired accuracy in radiation and unaccounted-for losses in a boiler test is a matter of the "purpose of the test." If the test is to determine whether the unit will meet the guaranteed efficiency, then an error of 2 or 3 per cent may be undesirable. If the test is to compare the performance and relative efficiency of two dissimilar types of units, then these items must receive consideration. But if the tests are to determine the relative merit of different methods of operation or the relative value of different fuels when burned in the same furnace, which is the more frequent purpose of testing, then what difference does it make if we assume 2 per cent or 4 per cent as long as we use the same figure in all of the tests to be compared?

The KEENAN *and* KEYES STEAM TABLES

By R. C. H. HECK

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THE PURPOSE of this review is to give a picture of the new Keenan and Keyes steam tables,[1] to discuss in a general way the formulation which they represent and to compare this latest formulation with the others that have been made in this country since 1910. The discussion will be informational, not going into specialistic questions of theory, manner of formulation, or conformity to experimental data. Quantitative presentation will be almost altogether graphical. The properties or "coordinates" to be considered are: Temperature (Fahrenheit) t, or absolute temperature $T = t + 459.7$; pressure p, lb per sq in. abs, volume v (represented by product pv), cu ft per lb; and enthalpy h, Btu per lb.

Wide-range diagrams of the tables appear in Figs. 1 and 2, which show the saturation boundaries and isotherms at each 100 F, with 20-deg dotted curves in the wide-spreading region above saturation. The vertical base is pressure p, the horizontal ordinate is either pv or h. The temperature range to 1600 deg is that of the tables, the pressure range to 6000 lb per sq in. runs 500 lb above the tables.

On the side of vapor saturation and of superheat the two diagrams are much alike, newly defining and extending previous information. On the liquid side they are very different in form, and this part of the presentation is an addition to previously available service information. Note that the crowded liquid isotherms below 600 F are omitted, for clearness of drawing. Curvature of the superheat isotherms disappears rapidly with rise of temperature; it is almost gone at 1200 F and the 1600-F line is straight.

The new tables differ from Keenan's graphical-numerical formulation of 1930 in that they come from definite and definitely related equations of state. These are of the general form

$$pv = f(T, p) \qquad \text{and} \qquad h = f'(T, p)$$

in contrast with the van der Waals type that makes p a function of T and v. As such they have a limited capability of following real behavior—being good up to perhaps half of critical pressure along saturation, but well above critical height farther out. In illustration of this matter, computed points on isotherms from 400 to 1000 F are shown by small circles on Fig. 1. Up to 700 F these are evaluated for coincident saturation values of T and p, locating the dotted path that the saturation curve would take if directed by the pv-T-p equation. Actual swing to the left is a feat of graphical-numerical adjustment to empirical data, with due use of thermodynamic relations.

The formulation on both sides of saturation is directly based on volumetric data; the measurement was of pressure against temperature in constant volume, and the highest temperature reached was 460 C or 788 F. The superheat equation for h was derived through thermodynamic relations but is closely confirmed by data in that field. See Fig. 1 of the book of tables. Extension above 800 F is, of course, an extrapolation beyond experiment, but by methods that are entirely valid. However, any detailed discussion of the steam equations, as to derivation or as to validity of range extension, is beyond the scope of this writing. Incidentally, the mathematical formulation is very elaborate and computation is a cumbersome process.

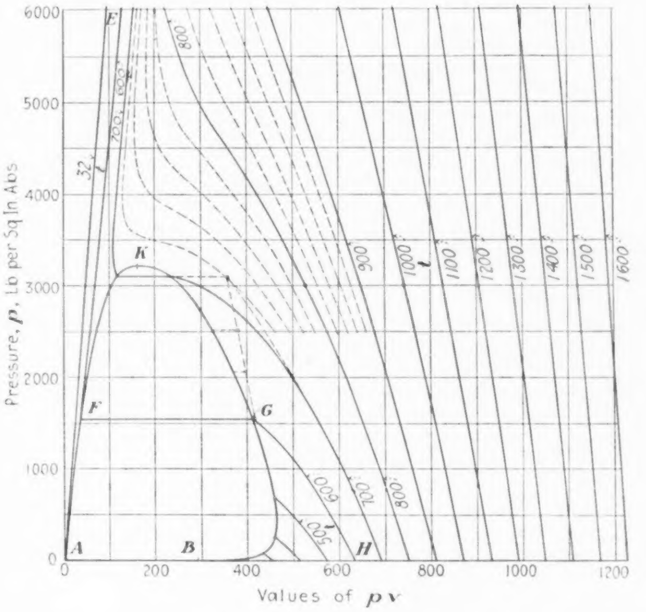

FIG. 1 ISOTHERMS OF pv ON p

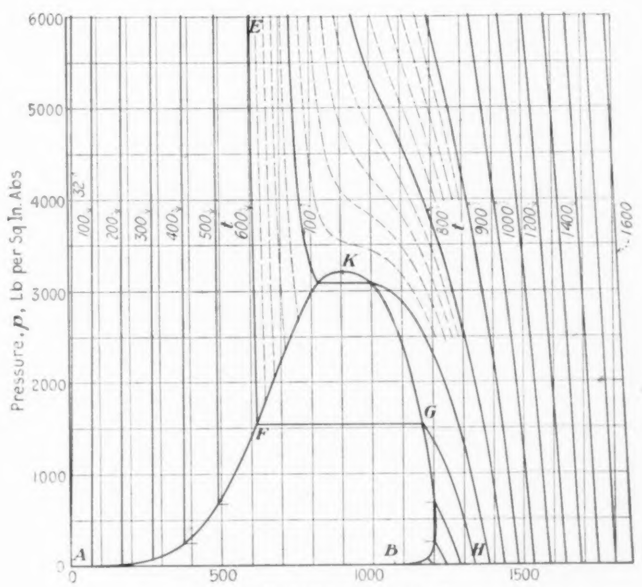

FIG. 2 ISOTHERMS OF h ON p

With the sole purpose of presenting information in clear and graphic form, without critical discussion, comparative curves of four formulations are given in Figs. 3 to 5, dis-

[1] "Thermodynamic Properties of Steam, Including Data for the Liquid and Solid Phases," by Joseph H. Keenan and Frederick G. Keyes. John Wiley and Sons, Inc., New York, N. Y. Cloth, $7^1/_2 \times 10$ in., 89 pp., with Mollier chart, \$2.75.

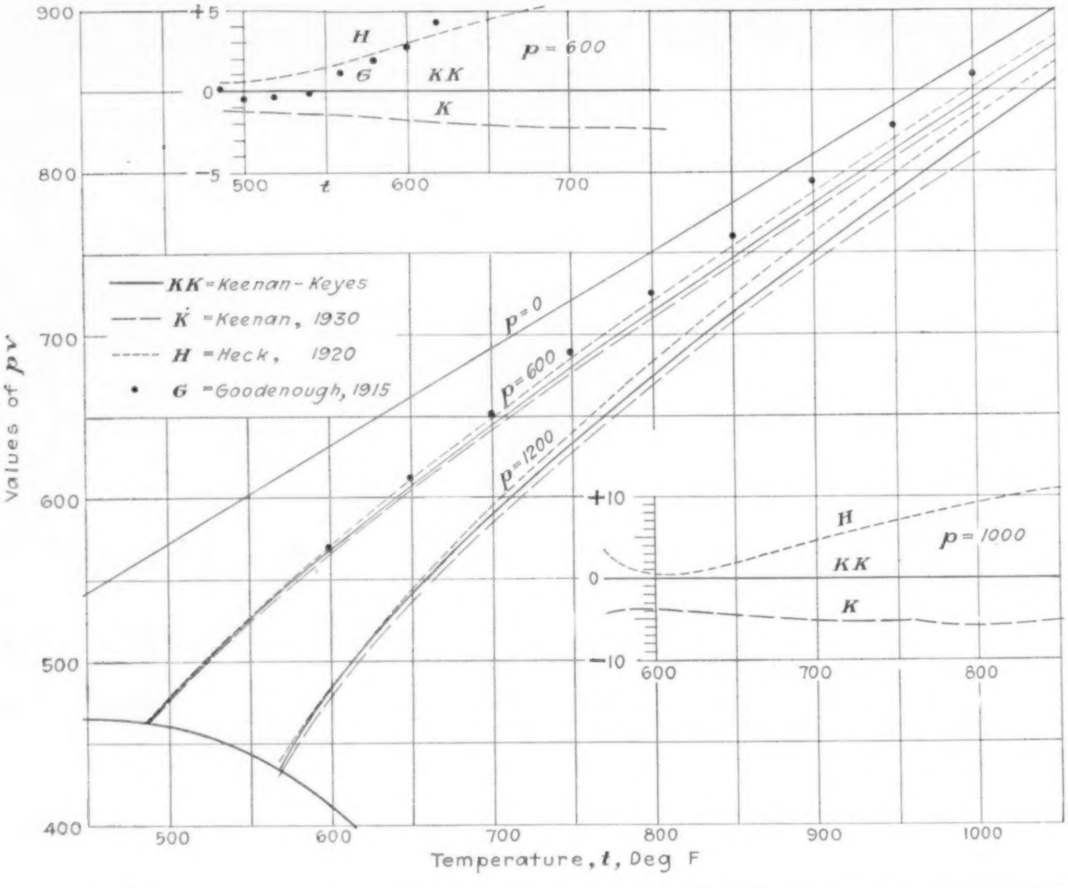

FIG. 3 LINES OF CONSTANT PRESSURE, *pv* ON *t*

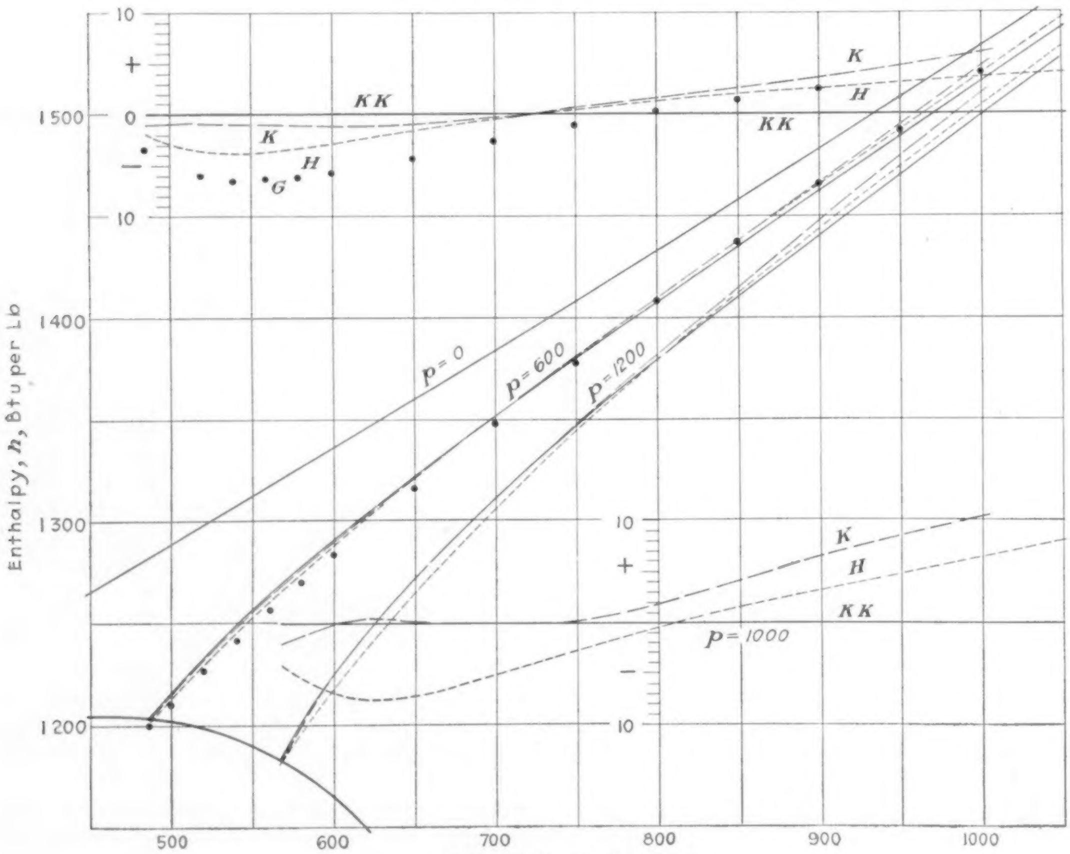

FIG. 4 LINES OF CONSTANT PRESSURE, *h* ON *t*

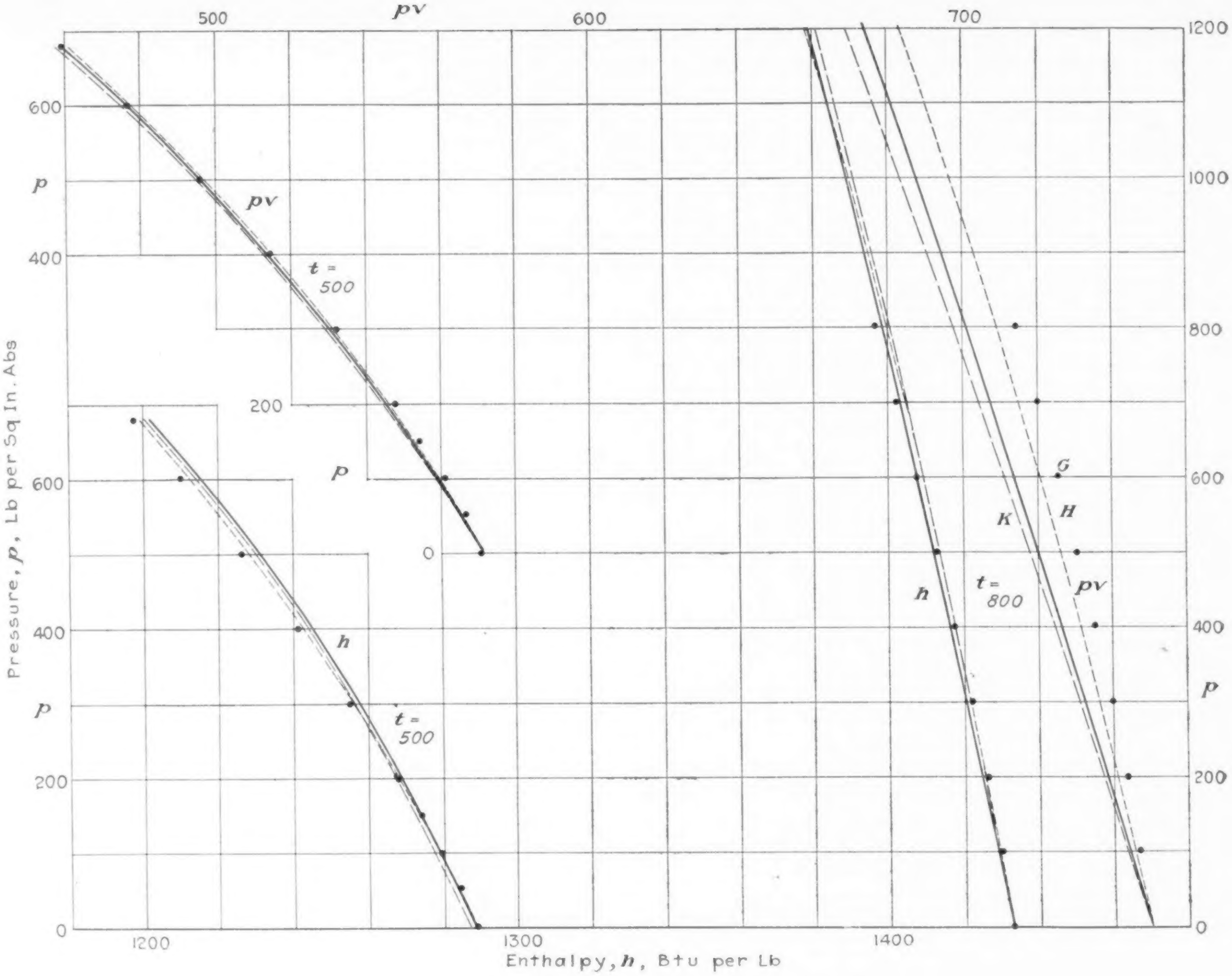

FIG. 5 COMPARATIVE ISOTHERMS, AT 500 AND 800 F

tinguished by the graphical notation stated in Fig. 3. These are

KK = Keenan and Keyes Tables, 1936, full line
K = Keenan tables, 1930, dash line
H = Heck, paper Steam Formulas, 1920, dotted line
G = Goodenough tables, 1915, heavy dots.

In Figs. 3 and 4 constant-pressure lines at 0, 600, and 1200 lb per sq in. are drawn for pv and for h; and also, to larger scale, departures from the *KK* values are shown by detail diagrams in the corners of the main drawings.

In Fig. 5 the two plots are combined, with easily distinguished scales. At the lower temperature the one for pv is displaced vertically, in order to avoid overlapping. In the field of specific volume the older formulations, which had no supporting data, now fare rather badly.

In the liquid region there is no question of comparison, since for water the new tables do what has not been done before. While rather abbreviated and not in shape for convenient use, the table for compressed liquid is a useful addition to service information.

In the range of low-pressure vapor—below atmospheric pressure and in the field of air conditioning and steam condensation—a notable change has been made. With the slope of the h-on-p isotherm at 212 F rather definitely fixed by throttling data, it has been difficult to accommodate zero-pressure h_0 to the range of saturation h_g down to 32 F. Goodenough and Heck found it necessary to adopt a formula for c_{p0} which made that limiting specific rise toward 32 F after passing a minimum. Keenan and Keyes have taken the fully justified step of cutting loose from the old data at 32 F and raising saturation h_g at that point from 1073.4 to 1075.8 Btu. The effect of this change is shown by the comparison in Fig. 6, which is a much magnified small portion of Fig. 2. Over the whole range from 212 to 32 F the *KK* and *H* formulations are shown, with the *K* isotherms also drawn in to about the lower limit of tabulation. Note how the dotted lines keep moving farther and farther to the left as temperature is lower.

TABLE 1 END POINTS OF ISOTHERMS IN FIG. 6

t	h_0	h_g	p_g	t	h_0	h_g	p_g
32	1076.0	1075.8	0.089	120	1115.1	1113.7	1.692
40	1079.5	1079.3	0.122	130	1119.5	1117.9	2.223
50	1084.0	1083.7	0.178	140	1124.0	1122.0	2.889
60	1088.4	1088.0	0.256	150	1128.4	1126.1	3.718
70	1092.8	1092.3	0.363	160	1132.9	1130.2	4.741
80	1097.3	1096.6	0.507	170	1137.4	1134.2	5.992
90	1101.7	1100.9	0.698	180	1141.8	1138.1	7.510
100	1106.2	1105.2	0.949	190	1146.3	1142.0	9.339
110	1110.6	1109.5	1.275	200	1150.8	1145.9	11.526
120	1115.1	1113.7	1.692	212	1156.2	1150.4	14.696

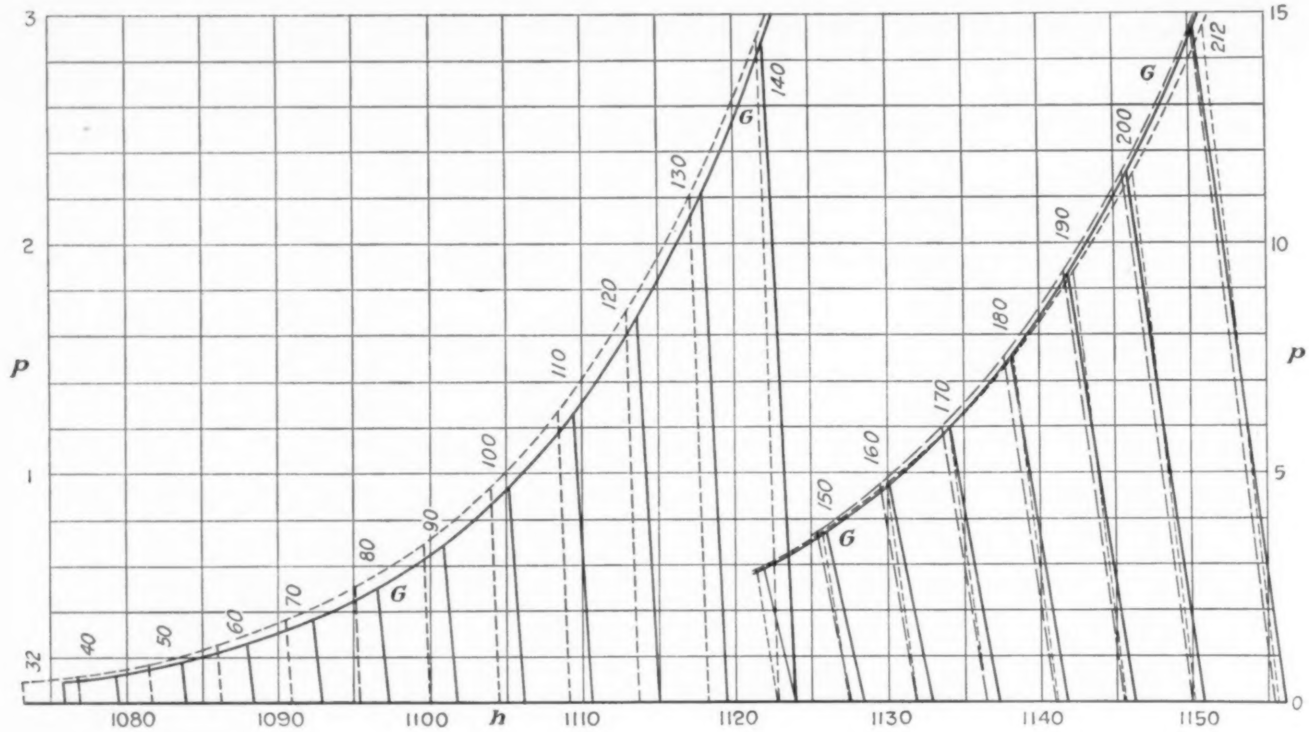

FIG. 6 THE RANGE OF LOW TEMPERATURE

The isotherms in Fig. 6 are not distinguishable from straight lines. For the new table or full-line plot the exact data are collected in Table 1, some of which are not available or not directly given in the published saturation or superheat table.

The dotted-line plot in Fig. 6 is well represented up to 120 F by using 0.460 for the average specific heat c_p of this low-pressure superheated vapor. The new formulation cuts this to 0.45 (perhaps to 0.445) as a mean value to be used in air-conditioning calculations.

The new tables are, of course, a great advance from the older formulations and a worth-while improvement upon the first Keenan tables. They are probably so near to absolute correctness that for engineering purposes a revision will not be desirable for a good many years.

Welded Boiler Drum Practice

BOILER plates up to 5 inches in thickness are now being employed in the construction of welded boiler drums. Where thickness exceeds 2 inches, a normalizing heat-treatment is applied to flat plates before forming, for grain refinement. Also, a subsequent drawing treatment is sometimes given to facilitate the forming operation when this is to be performed cold. The shaping of these heavy plates is done under hydraulic presses. This necessitates the use of two longitudinal seams. Since intermediate girth seams are not desirable in this type boiler drum, the shells for same are composed of two plates, each formed to approximate half circles. Shells exceeding 40 feet in length have been constructed by this method.

For reasons of economy, unequal thickness plates are frequently employed in such drums, the heavier section designed for areas to be perforated with tube holes and the lighter for unperforated sections or sections having a greater tube hole ligament efficiency. In this construction the heavier plate is tapered by machining to the thickness of the lighter, the machining being done so as to make the neutral radii equal and the neutral circumferences coincident. This planing operation, together with the machining of weld grooves, is usually performed after the plates have been formed into half cylinders. Similar machining of shell thickness down to head thickness and preparation of the girth weld grooves is usually done after the completion of the longitudinal seam welding.

The electric metallic arc method of welding, using heavily coated electrodes about $^1/_4$ inch in diameter, is the accepted practice. The design of weld joints for all main seams is the double butt type. Fillet welding is only permitted in the welding of nozzles, reinforcements and other external and internal attachments.

Weld metal is deposited in the grooves in relatively thin layers. The process leaves a heavy slag coating over these layers. This slag is thoroughly cleaned from each layer before depositing the succeeding one. Also, each bead is inspected for the removal of defects which cannot be eliminated in the succeeding operation. No actual peening of the layers is ordinarily necessary. However, peening is sometimes desirable under extreme conditions for the purpose of counteracting warpage and curtailing dangerous stresses pending thermal stress-relieving.

In finishing double butt welds, a small reinforcement of deposited metal is added to both sides of the plates. This reinforcement is subsequently chipped off and the surfaces ground practically flush with that of the plate. The purpose of this reinforcement is to obtain a full thickness section of refined weld metal. The excellent physical properties of such type joints are largely due to the heat-treating effect on preceding layers from subsequent depositions. After serving this purpose the reinforcing layers are removed from butt-weld joints as this added metal interferes with X-ray examination.—A. J. MOSES in *The Welding Journal*, November, 1936.

EBB *and* FLOW *in* AMERICAN UNIONISM

By RUSSELL NIXON

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

TOO MANY of us of late have observed that American labor is "at the crossroads" without having considered how it arrived there, or the location and setting of the point from which the present choice must be made. Leo Wolman's "Ebb and Flow in Trade Unionism"[1] (Volume 30 of the National Bureau of Economic Research Series) is the best (if not the only) general presentation of the immediate factual background of the forces of organized labor in the United States as they exist in these very crucial days. Dr. Wolman, who is professor of economics at Columbia University, and who was chairman of the Labor Advisory Board of the NRA, 1933–1934, member of the National Labor Board, 1933–1934, and chairman of the Automobile Labor Board, 1934–1935, writes the present volume somewhat as a supplement to his earlier book, "The Growth of American Trade Unions, 1880–1923."

The main body of this study consists of the presentation of authoritative figures of trade-union membership as a basis for interpreting the "ebb and flow" of the American labor movement. The statistical difficulties of this mode of measurement are emphasized by Dr. Wolman. The definite limitations of *any* such mere numerical data as a barometer of the prospects of a dynamic development such as the organization of the working class are not recognized adequately by the author, and it qualifies severely the quality of his supplementing observations regarding the more general problems of organized labor. However, the convenient statistical presentation is the most important aspect of this work, and with 36 tables, 5 charts, and a large appendix, this volume is a most useful handbook for the student of labor, as well as being pleasantly informative to one having only casual interest in labor.

From 1897 to the present time, Wolman finds five "well-defined phases" in American trade unionism revealed by figures of total membership during this period. These fundamental data may be summarized as follows:

Year	Average annual membership	Year	Average annual membership
1897	447,000	1923	3,622,000
1903	1,913,900	1933	2,973,000
1914	2,687,100	1934	3,608,000
1920	5,047,800		

As suggested by the table, the first phase, from 1897 to 1914, was one of steady growth. The second period, that of the war, from 1915 to 1920, was characterized by the enormous gain of almost 2,500,000 in union membership. This great growth was due especially to the widespread prosperity and intense demand for labor during the war and to the deliberate governmental policies which at this time furthered collective bargaining through the trade-union units.

The post-war depression of 1921–1922 ushered in the next phase of labor development in the United States by giving rise to such losses in membership as to put American trade unions back on the prewar level. After this first disastrous decline, the remainder of this period of 1921 to 1929 was one of almost continuous loss by organized workers. Even in the subsequent phase of the great depression labor continued to suffer even more, so that Wolman summarizes:

> Altogether the organized labor movement had, since the peak in 1920, lost 2,074,800 members, leaving it in 1933 where it had been in 1917, or, if the growth meanwhile of the working population of the United States be taken in account, in 1910.

Numerous factors are noted as having caused this decline during the prosperity of the 20's. Great shifts in economic activity seemed to thwart the efforts of the unions to keep up with the industries. An aggressive labor policy combined with certain features of "welfare capitalism" vitiated the working-class efforts. Unusual technical advance and mass-production methods increased the numbers of unskilled relative to skilled workers and led to difficulties of organization. Even while prosperity seemed general in those halcyon days, certain basic industries such as clothing, textiles, and coal mining were depressed throughout the 20's, thus adding another obstacle to union advance. Centers of production moved from union to nonunion areas, again thwarting for the time the efforts of labor to organize. Finally, Wolman suggests that "the structure and policy of the American trade unions" themselves, proceeding on the craft basis, were not adaptable to changing economic conditions facing labor in this period.

The "final" and present phase of labor development, marking the end of the persistent decline just noted, begins in 1933 and is ascribed to

> an extensive experiment in governmental control over the competitive practices of business and in labor legislation, not unlike the measures in effect during the World War.

Almost needless to say, the National Industrial Recovery Act with the now famous Sections 7*a* and 7*b* which provide for the collective bargaining relations between employer and employee are, for our interests, the most important part of this experiment. Above all, labor was recognized and given definite part in the administration of the codes as was especially shown by the union participation in the administration of the NRA label.

However, much labor legislation has augmented the NRA and hence outlived the Schechter case. The National Labor Relations Act (commonly called the Wagner Act) signed by the President soon after the famous Supreme Court decision of May 27, 1935, seeks to substitute for the NRA in its purpose to encourage the use of collective bargaining. It names as unfair labor practices by the employer (Section 8), (*a*) interference with the employees' right to organize, (*b*) domination or interference "with the formation or administration of any labor organization" or the contribution of "financial or other support to it," and (*c*) discrimination "in regard to hire or tenure of employment or any term or condition of employment to encourage or discourage membership in any labor organization." The National Labor Relations Board, created by the Wagner act, is to administer the law, and in this capacity has met with such large employer opposition as to vitiate many of its contributions. There is strong reason to suspect that the act itself may have met an adverse decision at the hands of the Supreme Court by the time this review is published. Such was the fate on May 18, 1936, of the Guffey act—the Bituminous

[1] "Ebb and Flow in Trade Unionism," by Leo Wolman, New York, National Bureau of Economic Research, 1936, 251 pp., $2.50.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers.

Coal Conservation Act—which combined regulation of collective bargaining and control of production and prices in this disturbed coal industry.

Dr. Wolman waxes extremely enthusiastic as he discusses "Unions Under Recovery Administration," and the close observer must read this section *cum grano salis*, wondering whether one so intimately immersed in the New Deal wave can correctly gage the extent and direction of this particular undulation as it affects the real ebb and flow in trade unionism. It is true that the Roosevelt administration has certainly voiced a new attitude toward labor on the part of government (but some one has written that, "The New Deal for labor has consisted largely in moving one speech forward and two steps backward!"). It is true, furthermore, that the two years following the enactment of the National Industrial Recovery Act saw a gain of some 900,000 in union membership. While relevant, these considerations are insufficient to enable one to make an adequate or proper evaluation of the prospects of labor organizations. In this volume the author's lack of a "philosophy" of the development of labor of a consideration of the broader aspects of a working-class movement, tends to restrict and distort Wolman's interpretations of the present situation.

The test of the New Deal's contribution to labor is not simply met by a consideration of the expressed attitudes of the particular political setup or by the superficial apparent gains of the membership and standing of organized labor. Any government the least bit removed from the extremes of blind reaction must have granted certain rights, if only in gesture, to a distressed and threatening labor population such as that in America during 1933. If New Deal labor sympathy and action were only momentary opportunism, then the recovery administration is one of labor's major tragedies, for by that ruse workers were deceived and lost thereby one of their greatest real opportunities for growth in strength.

Labor opponents to the New Deal point out that the NRA gave even greater impetus to company unions than to trade unions. It is certainly true that both the NRA and the Wagner Bill have legally left the way open for development of the company union. Without presuming to argue here for or against the company organization, it is sufficient to point out that in the eyes of many observers this development is so contrary to the interests of real organized labor as utterly to vitiate all other aspects of New Deal labor policy. The author errs not only in failing to recognize this issue, but even shows a sympathetic bias for the company plan. It is almost humorous to note that Wolman's observation that in representation elections under the NRA 53.1 per cent voted for representation forms other than trade union has to be radically amended by Bureau of Economic Research Director N. I. Stone because of its prejudiced nature due to the anti-trade-union method of voting adopted by the Automobile Labor Board of which Wolman was chairman.

A further objection often made to the NRA is that it is adapted to the craft form of unionization and hence espouses a sterile principle which precludes any far-reaching aid to labor in its efforts to organize. This problem, and with it the issue between the C.I.O. and the A.F.L., the author duly recognizes and discusses at length without apparently taking sides on the matter. However, even here, one senses an attitude at least not sympathetic with that part of American labor represented by John L. Lewis. The suspicion is especially strong when one notes that more than half of Wolman's "Introduction" consists of a direct quotation by William Green against Lewis and the C.I.O. with no statement by the latter therein contained.

The criticism levied against Wolman's consideration of New Deal labor policy, of company unions, and of the industrial-craft-union conflict is that his treatment is here inadequate and hence deceptive. Very possibly these problems cannot be definitively handled in an objective, scientific manner. If it is true that "time alone will tell," one must then refrain from idle prophecy, and, if he is to properly guide his readers, he can only present all sides as completely as possible. This Wolman has failed to do.

However, such shortcomings in this volume must not blind us to the great desirability of having its statistical and factual contents so well presented. Particularly enlightening is the description of the "Centers of Unionism" in this country. In all American labor history (with transient World War exceptions) "four groups of unions—transportation, building, coal mining, and printing—augmented by the established clothing organizations, have constituted the foundation of the American labor movement." As Wolman points out:

> The persistent juxtaposition of powerful and weak unions, the phenomenon of thoroughly organized trades and industries with adjacent occupations scarcely touched by organization, and striking geographical differences in the strength of membership have been outstanding features of the labor movement.

Fully as valuable is Wolman's comparison of the actual and potential membership of labor organizations, whereby it is sought "to derive as precise measures as possible of the extent to which the employees in all occupations together and in many of them separately have from time to time belonged to the unions of this country."

"Ebb and Flow in Trade Unionism" contains invaluable information conveniently presented. Knowledge of its contents is essential to one who would understand American labor, and he can nowhere find it as satisfactorily presented as in this latest book by Leo Wolman.

Diesel-Engine-Maintenance, Operating, and Outage Data

(*Continued from page 88*)

as caused by each outage item and shown in the last column of Table 4.

Generator outages, as expected, were a very small percentage of the total hours. Outages shown were accounted for largely by field windings, armature windings, vibration, exciters, and collector rings. Very few inspections were reported for generators, but it seems reasonable to expect that inspections required were made while engines were out of service for inspection or repair.

Auxiliary-equipment outages show that 32.9 per cent of the total was due to the exhaust system, while 22.8 per cent was due to water-cooling system, 17.2 per cent to lubricating equipment, 10 per cent to air compressors, and 4.6 per cent to fuel-oil equipment. There were, however, few machines affected by outages due to auxiliary equipment. Repairs and maintenance of auxiliary equipment did not cause interruptions, because in most cases duplicate auxiliary equipment was available.

Outages for other causes were accounted for principally by piping and plant electrical equipment. Outages for other causes vary in nature from year to year, and no particular significance is to be attached to the figures presented.

[NOTE: The discussion of this paper at the time of its presentation, brought out some points of view that differed from those expressed by the author. This discussion with any other that results from this publication of the paper, will be presented with Mr. Schneitter's reply in a later issue, in accordance with our usual procedure.—EDITOR.]

AMERICAN POWER PRACTICE

Comments by Discussers on Papers Presented Before the A.S.M.E. Power Division at Niagara Falls, September 18 to 20

OUR ISSUE of September, 1936, was devoted to five papers on American power practice, all but one of which were contributed by the Power Division and presented at the Niagara Falls meeting, September 18 to 20, of The American Society of Mechanical Engineers. The widespread interest that these papers evoked is demonstrated by the amount of written discussion on them that has been received upon which the following report has been based. For the convenience of the reader, brief summaries of the four Niagara Falls papers have been prepared to introduce each group of discussions.

Time has not permitted the authors of the papers to prepare comments on the discussions. It is hoped that these may be published in a later issue.

I—DEVELOPMENT AND PERFORMANCE OF AMERICAN POWER PLANTS, BY A. G. CHRISTIE[1]

Professor Christie's paper covers 13 major topics: Power development, power costs to consumers, power interchange, water power, internal-combustion engines, steam-power plants, steam turbines, condensing plants, piping, steam-station power costs, mercury-vapor plants, electrical switching and conclusion, to which was appended a bibliography of 23 references. By far the major portion of the paper is devoted to steam power. A notable feature of the paper is its statistical material, presented in the form of three tables. One of these is devoted to recent large hydroelectric plants in the United States and Canada. Another gives performance data on 12 American power stations for the period January 1 to December 31, 1935. The third gives data on 29 recent generating installations. Cross sections of typical plants and turbogenerators are included.

Discussion on Professor Christie's paper follows:

DISCUSSION BY P. W. THOMPSON[2]

Among the stations mentioned by Professor Christie as an example of reconstruction of old stations is the Conners Creek plant of The Detroit Edison Company. A few additional details may be of interest.

The old station began service in 1915 with one 20,000-kw turbine. The steam conditions were 220 lb per sq in. and 600 F. Two additional 20,000-kw turbines were added shortly thereafter. By 1920 the generating capacity was made up of these three 20,000-kw machines, two 45,000-kw, and one 30,000-kw unit, or a total of 180,000 kw. This capacity was served by steam from 14 boilers. The plant produced a kilowatt hour for approximately 19,000 Btu (annual basis).

It was apparent prior to 1929 that the load served from the Conners Creek plant would increase and that additional generating capacity would be required.

The reasoning which led to the rebuilding of the plant with steam conditions of 600 lb per sq in. and 825 F rather than to the construction of a new plant is given in a series of articles by Sabin Crocker and published in *Combustion*, November, 1935, to June, 1936.

Lower loads during the depression years caused a general curtailment of power-plant construction. However, it afforded an excellent opportunity to remove old capacity from service at Conners Creek, and advantage was taken of the condition to proceed with the rebuilding.

To date three old 20,000-kw turbines have been rebuilt to 30,000-kw units, four new boilers have been installed, and a new 24-kv switch house has been built adjacent to the power house. A 60,000-kw turbogenerator is being erected in a new extension to the turbine room and two new boilers are practically completed and will be ready to supply steam by Oct. 15, 1936. A second 60,000-kw turbogenerator with its complement of two boilers is scheduled for service in the late fall of 1937.

It should be pointed out that items 20 to 30, inclusive, referring to Conners Creek in Table 2 of Professor Christie's paper are for the 12-month period, May 1, 1935, to April 30, 1936. The annual station performance of 13,000 Btu per net kwhr reflects the improvement in thermal performance effected by the use of the new equipment. The figure given is the overall performance of the old and new portions of the plant, both of which were in operation during the 12-month period. During the four-month period of March to June, 1936, the old section, with the exception of one banked boiler, was not in operation, and the Btu per net kwhr for the period was 12,450.

Almost three years have elapsed since the paper on "High-Temperature Steam Experience at Detroit"[3] was presented before The American Society of Mechanical Engineers. As the experiment with 1000 and 1100 F steam has about run its course, this opportunity is taken to report the findings to date.

The 10,000-kw, 1000-F turbine and separately fired superheater installed at the Delray plant have been in service a total of 25,470 hr, 21,938 hr of which have been at 1000 F. The additional 14,106 hr of service at 1000 F obtained on the unit since September, 1933, has served to confirm the conclusion stated at that time to the effect that reliable service may be expected with turbines operating at 1000 F, provided, as in this case, high-temperature resistant-alloy materials are used, and provided the working stresses are conservative. As evidence of this, the 10,000-kw unit with its superheater had an availability factor of more than 78 per cent during the 20-month period preceding Feb. 14, 1936, when the unit was placed in reserve.

The small 1100 F separately fired superheater at the Trenton Channel plant has now completed 36,378 hr of service at 900 F to 1100 F, the major part being at 1100 F. The additional 15,000 hr of service obtained on this superheater since September, 1933, has served further to prove the adequacy of the 18 per cent Cr, 8 per cent Ni material used in the tubes and experimental pipe line. A section of tube examined after almost 36,000 hr indicates that this material should continue to give

[1] MECHANICAL ENGINEERING, September, 1936, pp. 539–561.

[2] Chief Engineer of Power Plants, The Detroit Edison Co., Detroit, Mich. Mem. A.S.M.E.

[3] "High-Temperature Steam Experience at Detroit," by P. W. Thompson and R. M. Van Duzer, Jr. Trans. A.S.M.E., vol. 58, 1934, paper FSP-56-9, pp. 497–514.

satisfactory service for an indefinite period. The impact strength was found to be 30 per cent higher than that of the tube tested after 21,000 hr. Apparently, the deterioration evidenced by the drop in impact value and increase in hardness noted at the 21,000-hr period has been arrested. Resistance to intercrystalline corrosion has also increased as determined by change in electrical conductivity of a sample in a boiling Strauss solution.

A specimen of 4 to 6 per cent Cr, 1 per cent W tubing removed after 19,000 hr at 1000 to 1100 F was found to have softened slightly giving a reduction of about 3000 lb per sq in. in the tensile strength and a reduction from an Izod value of 39 ft-lb to 34 ft-lb. Changes in the other physical properties were not detected. These findings tend to confirm the statement made in reporting experience with the cast 4 to 6 per cent Cr, 1 per cent W material that noticeable embrittlement of this material did not occur in steam service at 1000 to 1100 F. Incidentally, it was found possible to make a satisfactory butt weld between this 4 to 6 per cent Cr, 1 per cent W tube and a length of 1.24 per cent Cr, 0.58 per cent Mo, 1.40 per cent Si tube using "Cromansil" electrodes and annealing the joint at 1400 F.

The composition and physical properties of the manganese-molybdenum casting used for the replacement throttle valve for the 10,000-kw unit was not available at the time the 1933 paper was written. Because of the present rather general tendency to select carbon-molybdenum and manganese-molybdenum material for 900 to 950 F service, the following analysis and physical properties of the valve-body casting which has been in service at 1000 F for some 14,000 hr is included:

MANGANESE-MOLYBDENUM VALVE-BODY CASTING, CHEMICAL COMPOSITION

Carbon, per cent	0.20–0.30
Manganese, per cent	1.15–1.30
Molybdenum, per cent	0.30–0.50
Silicon, per cent	0.25–0.40
Sulphur and phosphorus, per cent	0.05 (max)

PHYSICAL PROPERTIES AT ROOM TEMPERATURE

Tensile strength, lb per sq in.	67,500
Yield point, lb per sq in.	38,300
Elongation, per cent	17
Reduction of area, per cent	40

While metallurgical examination of this material has not been made, there is no evidence of any shortcoming. As a matter of fact, the same can be said of all the materials used in the Delray installation with the exception of some 8.5 per cent Cr, 3.5 per cent Si nuts on the control-valve-bonnet joints which were replaced with carbon steel after they were found to fracture during disassembly, and some 18 per cent Cr, 2 per cent Ni stainless-steel control-valve stems which are also in an extremely brittle condition. The brittleness of the valve stems has not caused any trouble except when one stem was broken during a straightening operation, but greater toughness and better ductility would be desirable for such service.

Pipe joints and valve-bonnet joints have continued to be a source of trouble. Little additional information has been secured from the Trenton Channel installation as some of the light flanges continue to leak after relatively short service periods while the modified 900-lb and 1500-lb flanged joints have remained tight for over 30,000 hr with 1000 to 1100-F steam. The ring-type bonnet joint on the replacement throttle valve of the 10,000-kw unit had to be remade after 6300 hr of service. The Armco oval ring gasket was found to be badly corroded and the bolts had elongated an average of 0.0164 in. Since the bolts were initially strained only 0.006 in. in making up the joint, the temperature difference between flange and bolts must have been large and the compression required on this type of gasket almost negligible for the joint to have functioned under these conditions. An oval monel ring was substituted for the iron ring to prevent corrosion and Seminole Hard bolts (alloy 11)[4] were used in place of the nickel-chromium-molybdenum bolts. There has been no trouble with this joint in the succeeding years' service.

The bonnet joints on the center pressure valve near the outlet of the superheater necessitated three shutdowns during this period. As this valve was designed to conform more or less to the A.S.A. 600-lb standard, these bonnet flanges are lighter than presumably would now be used for 400-lb, 1000-F service if made of a material such as this low-chrome-high-molybdenum analysis (alloy 10). The end flanges of this valve have been assisted to some extent by the large hairpin springs. However, these spring-compensated joints, possibly because of the low gasket pressure which could be obtained on the metal gaskets, have not been entirely successful. The springs were removed from one of these joints and the joint made up in the regular way when leakage occurred last August. This joint without springs has remained tight for more than 4000 hr at 1000 F.

Even joints approximating the 1500-lb standard in the Delray installation have not proved to be entirely immune from trouble. The No. 2 pipe joint which is the 8-in. joint between a cast 4 to 6 per cent Cr, 1 per cent W reducing elbow (alloy 7) and the 18 Cr-8 Ni Van Stoned pipe (alloy 2) leaked after about 4000 service hours. Leakage apparently occurred as the result of creep of the bolts and indentation of the gasket ring into the 18 per cent Cr, 8 per cent Ni Van Stoned lap. The bolt stress was found to have decreased from the initial stress of 40,000 lb per sq in. to approximately 10,000 lb per sq in. The residual gasket pressure under this condition was about eight times the SSP with pressure acting. Apparently a gasket pressure in excess of eight times the SSP was necessary in this case to keep the metal gasket in intimate contact with the joint faces since leakage occurred under this condition.

The joint between the 10 × 8-in. reducer (alloy 6) near the superheater which has the same flange design also had to be remade last August. In this case, the joint consists of a carbon-molybdenum casting, 18 per cent Cr, 8 per cent Ni Van Stoned lap and a chrome-nickel companion flange. Both of these joints have been free from trouble during the last year.

If any general conclusion can be drawn from the company's experience with bolted joints at 1000 and 1100 F, it is that less trouble can be expected with extremely heavy construction, and that welded joints should be used where possible.

The conclusions given in the 1933 paper as to the feasibility of stations designed for 1000 F have not been affected by the additional service hours obtained on the two high-temperature installations. However, the need for high-temperature resistant materials is no less evident than when the high-temperature steam experience was first described.

DISCUSSION BY E. G. BAILEY[5]

In reading Professor Christie's paper the outstanding impression is the diversity of equipment which goes to make up the steam-generating units of today. A part of this difference is due to the likes and dislikes on the part of some of the buyers. Sometimes it is due to space limitations. Again it may be due to the peculiarities of the fuel which it is expected will be burned during the life of the unit. Another reason is there are more tools to work with, such as a larger variety of furnace-wall constructions, many kinds of stokers, pulverizers, burners,

[4] See Table 1 in reference of footnote 3.

[5] Vice-President, Babcock & Wilcox Co., New York, N. Y. Mem. A.S.M.E.

and methods of trying to handle the ash in the coal being burned.

In spite of all this diversity of opinion and multiplicity of ways of doing substantially the same thing, one is impressed with the fact that there is not likely to be a very large number of new tricks thrown into the competitive ring, and shortly there will be, by process of test and elimination, a narrowing down of the diversities toward a recognized survival of the fittest.

Already, as Professor Christie brings out, there is an increasing trend toward water-cooled furnaces; pulverized coal seems to be gaining over stokers, and the direct-firing method of burning pulverized coal is more popular than the bin-and-feeder system, and turbulent burners are generally used. There are only two forms in which ash may be taken out of a furnace, one is dry, the other is molten, and in between it just does not come out. It is better to have a little delay in ash removal at low ratings than to get into this difficulty at high ratings where a dry bottom does not always remain dry.

Professor Christie speaks of the wide divergence in the relative proportion of the parts of the steam-generating unit, combustion rates, and conditions, further saying that there is no accepted standard division of the heating surface between waterwall, convection boiler, superheater, economizer, and air heater. If a uniformly clean fuel such as natural gas were always used, these differences would quickly diminish, but coal with its troublesome ash is the prevailing fuel, and many variations in design result from differences in the coal ash and its fusing temperature.

The outstanding problem in burning coal is to collect as much ash in the furnace as possible, remove it from the furnace cheaply, eliminate the slagging and coating of the heating surface, and reduce the discharge from the stack. The advantages of slag-tap furnaces with respect to each of these factors have been widely recognized for the larger boilers, and to further extend their usefulness the furnace designs of Figs. 10 and 11 of Professor Christie's paper have been recently developed. The first stage of the furnace is relatively small and the water-cooled walls are faced with a durable refractory so that a high furnace temperature is obtained. This results in rapid and effective combustion over wide rates of operation and a high percentage of ash recovery within the slag-tap furnace, which is readily tapped continuously or intermittently. The radiant heat from the burner zone is shielded from the boiler and superheater convection banks by the arrangement of the furnace slag screen, greatly diminishing slagging or birdnesting within these banks. Ash particles, like thermocouples, usually remain hotter than their carrying gases so long as they receive radiant heat from the flame near the burners, but take on a lower temperature than the gases when shielded from this radiant heat and surrounded by cooler surfaces.

The open-pass boiler of Fig. 11 of the paper under discussion is really not a boiler in the usual meaning of the term. It consists of a high-duty slag-tap furnace, and the gases are cooled several hundred degrees as they travel up and down through the two open passes and enter the bottom of the superheater on the same elevation as the bottom of the furnace and only a short distance away. The furnace heat is well shielded from the superheater bank, and no bank of boiler tubes exists. There is a total gas travel of about 70 ft from the burners to the entrance to the superheater. Turns and turbulence in the gas passage insure complete combustion. The arrangement is well adapted to low headroom sometimes desirable in superposition installations.

With higher steam pressure and temperature the boiler convection surface is small, especially where water-cooled furnaces are used; boiler surface cannot economically be used beyond the superheater, therefore the straight tube or sectional-header boiler is still useful, and as Prof. Christie says, the circulation is readily made ample by proper design.

The high temperature of steam obtained in modern superheaters calls for superheat control, shielding of the superheater from direct radiant heat, draining of the superheater at all times, and its protection by by-passing the gases when starting up the boiler unit.

The treatment of feedwater, especially in industrial plants with raw-water make-up, is most important. Some interesting experiments indicate that waterwall and boiler surfaces subjected to direct radiant heat should be protected against excessively high rates of heat input to guard against tube losses through formation of scale or sludge.

Water-level recorders and controls are fast becoming accepted as an operating necessity. The cleaning of steam has made rapid strides in recent years and is subject to still further improvement.

DISCUSSION BY HANS DAHLSTRAND[6]

The data on thermal performances given by Professor Christie are interesting. With this information, comparison between the various types of cycle arrangements can be made, and with definite limits of steam conditions now considered safe, the designers are in a position to estimate accurately the expected performance and design power plants that will give the highest returns both efficiently and economically.

Steam conditions adopted in various plants are just as far from being standardized as ever. The reason for this is, of course, the search for higher economies. Apparently, no definite limits are even thought of; consequently, equipment exposed to these conditions will continue to be special. Up to the present no special difficulties in the adoption of higher temperatures and pressures have been encountered, as the designs and arrangements have been changed to meet the new conditions. There is undoubtedly a limit to both steam pressure and temperature beyond which no further gains in efficiency can be obtained, and the economic limit will probably be much lower due to the increasing costs of equipment.

In the large number of superposed plants now being built the limit of pressures and temperatures for the superposed turbine are determined by the conditions for which the older equipment was designed. The operating cycle, however, cannot be altered to a great extent; consequently the increased efficiencies from the regenerative and regenerative-reheat cycles adopted in new plants are not fully realized in the superposed plants.

The newer power plants with high pressure and temperature are operating with practically no difficulties, and adding all the equipment required for the regenerative and regenerative-reheat cycle has not complicated operation to any considerable extent judging by the long periods of time these plants can be operated without shutdowns and by the fact that they can be shut down and started at short intervals. From all of this experience it is only natural that higher pressures and temperature will be adopted in new plants. At present it seems that the regenerative cycle will be used for these plants eliminating the complication of reheating.

The most efficient power plant today uses the regenerative-reheat cycle.

In order to obtain an equal efficiency using the regenerative cycle it is necessary to adopt steam temperatures beyond what is considered safe at the present time. The question is, then, whether we have exploited the regenerative-reheat cycle far enough. The complication of operation does not enter into

[6] Engineer, Charge Steam Turbine Dept., Allis-Chalmers Mfg. Co., Milwaukee, Wis. Mem. A.S.M.E.

the consideration and therefore it is only the question of costs. The problem of boiler design has been solved so that a constant temperature at the main steam outlet and reheat outlet is obtained during large variations in steam flow. Besides, the reheat temperature can be fixed so that only a limited amount of moisture will exist in the exhaust, thereby not only reducing blade erosion but also increasing the efficiency of the turbine blading in the lower stages. The steam turbine for this type of plant can, of course, use just as high initial pressure and temperature as in the regenerative plant. The additional cost of reheat piping and other equipment required does not represent a large percentage of the total cost of the power plant, and therefore may not be the determining factor in selecting the most economic operating cycle.

DISCUSSION BY M. K. DREWRY[7]

Reference by Professor Christie to Mr. Morrow's conclusions that seven years of recent development have netted no reduction of power-generation costs may deserve qualification. It is obvious that had not thermal economy actually improved markedly, the stated comparison would have been still less favorable.

Comparison of 1934 operating conditions with those of 1927, and of a group of new plants with total unit output costs varying more than 2 to 1 even when corrected to the same load and coal-cost conditions, has limited the scope of Mr. Morrow's conclusions, as he states in the original publication.

General acceptance of the spirit of this paper, namely, that true progress characterizes the power industry, will help to improve our living conditions.

CLOSURE BY A. G. CHRISTIE

This paper forms a voluminous review of the present situation and has caused much informal discussion that will not appear in the publications of the A.S.M.E. Such interest will direct attention to many power-plant problems and must lead to a better understanding of the present trends in power development.

Mr. Thompson's additional data on Conners Creek supplements the meager statements in the paper. Its recent four-month performance of 12,450 Btu per kwhr is excellent for such a plant. His further data upon experiences with steam at 1000 F are valuable, as such practical information influences others to adopt higher steam temperatures. Apparently the reliability of equipment with such temperatures is definitely established. Pipe joints and valve bonnets have given some trouble, which might be eliminated in future installations by the more extended use of welds.

Mr. Bailey desires greater standardization of equipment. While it is true, as Mr. Bailey points out, that certain trends are evident in present-day plants, one cannot assume that these represent any degree of finality. For instance, forced-circulation boilers are receiving much study abroad and attempts are being made to introduce them in this country. Mr. Bailey's discussion of the new boiler constructions shown in Fig. 10 and 11 present much interesting information in addition to that in the paper itself. These types of boiler will be widely used in new plants and such data is particularly welcome.

Mr. Dahlstrand's contribution confirms the opinion that no serious difficulties have been experienced with high steam pressures and temperatures. He favors the regenerative-reheating cycle, though economics must influence the final decision on choice of cycle.

Mr. Drewry points out that power-production costs have not increased in recent years, due to the steady improvement in thermal economy. Engineers should give this statement wide circulation among the general public.

A past-president of the Institution of Mechanical Engineers, in a private letter discussing this paper, points out that Americans consider dust removal from flue gases as a desirable objective, while in England gas washing to remove the sulphur gases as well as dust is deemed necessary. He states that more definite information is needed regarding the efficiency of steam scrubbers. The increasing expense of accessories and auxiliaries and particularly of electrical apparatus deserves the concentrated study of engineers as a means of reducing plant costs.

II—SUPERPOSITION, BY E. H. KRIEG[8]

Superposition, which, simply expressed, is a method of cross-compounding by exhausting a new high-pressure turbine (600 to 1400 lb) to existing turbines (usually about 200 lb), is reviewed by Mr. Krieg. The paper considers first where superposition has been applied, where it is being applied, and where it can be applied. A table of relatively complete data covers the 4 existing installations, while another provides statistics on 9 superposed power plants operating on pressures up to 825 lb, and on 13 plants for pressures around 1200 lb. Three other tables give data on turbogenerator availabilities. Such topics as investment, size of turbogenerator, single-boiler plants, availability, maximum output, incremental cost, fuel costs, and plant cycle development, including studies for the Logan station, are discussed. Consideration is given to the limitations of superposition, and ten advantages of superposition are briefly summarized.

Discussion on Mr. Krieg's paper follows:

DISCUSSION BY G. B. WARREN[9]

Mr. Krieg's paper, together with that entitled "A Superposed Power Station" by D. S. Brown[10] of the Union Gas and Electric Company of Cincinnati, forms a valuable foundation upon which, I dare say, many other engineers may be able to base their studies for future power-plant additions.

One of the outstanding factors with respect to the rebuilding of the Logan plant of the American Gas and Electric system has been the superimposing of a high-pressure unit of more than 85 per cent of the capacity in low-pressure turbines. Mr. Krieg describes in some detail how this is done, it being essential to heat the feedwater in steps by means of steam in the main not bled from the low-pressure units but exhausted from the auxiliaries, which, in turn, operate on steam which has passed through the high-pressure turbine. I would like to emphasize the advantages of this arrangement as far as certain aspects of the matter are concerned.

In the first place, this method of operation of the auxiliaries furnishes nearly enough steam to take care of the feedwater heating cycle without extracting from the low-pressure units. This eliminates the necessity of making extensive and difficult changes on turbines which may be already installed but which are not now adapted to bleeding. Furthermore, it permits the use of lower pressure, lower temperature auxiliary turbines with resultant lower first cost, reduced development, and higher auxiliary-turbine efficiencies. The question of control over a reasonably extensive load range may present some difficulties, but I am confident it can be satisfactorily answered. I am not suggesting that it is superior to the solution arrived

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[8] MECHANICAL ENGINEERING, September, 1936, pp. 562–572 and 584.

[9] Designing Engineer, Turbine Engineering Department, General Electric Company, Schenectady, N. Y. Mem. A.S.M.E.

[10] MECHANICAL ENGINEERING, September, 1936, pp. 585–590.

at by the New York Edison Company in the Waterside development in which the extraction turbine is mounted on the same shaft as the high-pressure turbine and which accomplishes many of these advantages, but it is at least another solution and one well worthy of consideration in any rebuilding studies being undertaken.

I sometimes think that engineers are so close to these problems that they may not see the full implications of some developments. For instance, I am somewhat at a loss to understand why the public utilities are not pointing out to the general public the full significance of Mr. Krieg's opening sentence in his paper: "By means of superposition, 4000-Btu-per-kwhr capacity is added to an existing plant at a cost of from $80 to $110 per kw, so that a plant performance of, say, 24,000 Btu per kwhr is decreased to 12,500 Btu per kwhr." This means to me that the public utilities are in a position to add two to three million kilowatts of new generating capacity to meet this country's needs at a cost of from $80 to $110 per kw which will have practically a zero fuel consumption chargeable to the new capacity so added. So far as I know, there is no remaining water-power development in this country which can approach these figures.

Further, it is interesting to note that in the list of superposed power stations constructed or under construction and which represent one of the most important forward steps taken in power-plant design, all of the stations represented are privately owned public utilities.

DISCUSSION BY J. A. KEETH[11]

Mr. Krieg has presented an excellent case for the superposed station but has been careful to show that it may not be a cure-all for the obsolete or undercapacity station, and points out that each case must be considered as an independent problem. He has presented data showing quite conclusively that high availability can be obtained both from high-pressure boilers and high-pressure turbines. It might be well to emphasize, however, that the availability figures given largely cover equipment operated at temperatures between 700 and 750 F. The Hawaiian Electric Company and the American Light & Traction Company have the only two installations listed in Table 2, operating at 800 F or above, that have been in service long enough to be any indication of the effect of higher temperature on maintenance. The Public Service Electric & Gas Company installation, an 825-F plant, has had only about three years of service and with the exception of the Detroit Edison Company's first experimental installation, probably no other station has had longer experience with higher temperatures. It is possible that longer use of higher temperature steam may adversely affect the availability factor of both the superheater and turbine and in turn increase maintenance. It will be interesting to note the service record of these higher temperature units over the same number of years that present records cover for the lower temperature units.

It is likewise possible that piping may not show up so favorably under the higher temperatures, although it is believed that the increased use of welded joints will eliminate what might be the chief source of piping maintenance.

Mr. Krieg has discussed the subject of single boiler installations and has pointed out two conditions where the single boiler unit is not the one that is best adapted. It seems that he might have added one other condition possibly favoring two or more boiler units. Certain mid-western coals exhibit much more serious tendencies toward slagging the gas passes of boilers, superheaters, and economizers than do some of the eastern coals. While great strides have been made in designing heat-absorbing surface so as to minimize this trouble and also toward providing better access for cleaning and lancing, it still seems probable that fouling of the gas passes may mark the limit of continuous runs of boilers operating on these types of fuels and may be the cause of more frequent boiler outage than of turbine outage. Under such conditions the engineer might do well to consider seriously two boiler units instead of one.

Superposition may be accompanied by an operating problem which will affect adversely either the unit-capacity factor or availability factor. This is the problem of carry over and fouling of turbine blades. Mr. Krieg has possibly concluded that enough is known of this phenomena now that it can be avoided. It is probably true that most high-pressure stations that encountered it initially have overcome the trouble or reduced its seriousness to a point where it is no longer important. However, it is a fact that practically every station has followed a different method of solving this trouble and has succeeded only after long periods of experimentation. Evidently, much is yet to be learned about carry-over and means of preventing it so that a word of warning on this subject may not be amiss.

Mr. Krieg's comments on incremental costs are particularly important and a vital factor in any superposed installation, although it likewise plays an important part in the economics of any plant change or addition. It is seldom that an improvement in one plant is not accompanied by a loss in another on the same system. The net result to the economy of the system must be considered rather than the effect on a single station.

The description which Mr. Krieg gives of the heat-cycle studies for Logan station is of interest and emphasizes strongly how difficult it is to cover the almost limitless variations in heat cycles which will be possible in the different stations where superposition may be applied. It is in this phase of the work that the engineer has the most fertile field for his ingenuity. Mr. Krieg's analysis of his auxiliary drive problem is unique and evidently admirably suited to the case in hand.

Present-day superposition will naturally result in much better overall plant economies than were possible in earlier installations such as that of the Kansas City Power and Light Company. In 1927, when this installation was engineered, 10,000 kw represented about the largest capacity high-pressure turbine available and even that size bordered on pioneering. In Kansas City the superposed unit represented but a small percentage of the station capacity, actually only 12.9 per cent as compared with 85 per cent in the Logan station. The Northeast station superposed unit was intended essentially as a base-load unit and required a fairly high load factor to justify it, particularly at the low prevailing fuel prices. The installation cost was high owing to necessary alterations to building, use of forged-steel boiler drums, and the necessity of using reheat because of the relative high steam temperature of the existing plant, that being 700 F. The plant was low on boiler capacity so that a fairly large part of the superposed investment could be justified on the grounds of added boiler capacity.

The development in the use of higher steam temperatures has undoubtedly greatly broadened the field of superposition. In some instances it may even have value as applied to the older superposed installations. An example of this is the Northeast station of the Kansas City Power and Light Company.

In this station, advantage will be taken of higher steam temperature in remodeling of the existing high-pressure installation. One of the chief sources of maintenance and cause of boiler outage at that station has been the short life of certain radiant reheater elements in the two furnaces. The furnace walls were of such size and design that little or no opportunity

[11] Mechanical Engineer, Kansas City Power & Light Company, Kansas City, Mo. Mem. A.S.M.E.

existed for improving the present reheaters. Neither did the boiler design permit the installation of any portion of convection reheater surface to replace that part of the radiant surface subject to the high maintenance.

Fortunately the high-pressure turbine was constructed for operation at temperatures up to 850 F, although its designed operating temperature was only 725 F. New superheaters have been purchased for the existing high-pressure boilers to raise the steam temperature to 825 F. This higher throttle temperature will raise the turbine exhaust temperature (reheater inlet temperature) sufficiently so that those reheater elements subject to the high maintenance can be removed and the 700 F steam temperature still be maintained for the old turbine. This increase in steam temperature going to the high-pressure unit will result in an improvement in its economy which will result in carrying a slightly higher load with the same steam flow.

Mr. Krieg's conclusions are concise and much to the point. His paper cannot help but prove valuable to the many who are considering superposition and is certainly of interest to all power engineers.

CLOSURE BY MR. KRIEG

Mr. G. B. Warren's comments are indeed well taken. As he mentions, the problem of cycle control with turbine-driven auxiliaries demands some thought and ingenuity. Briefly, the problem arises from the fact that the steam demand of the auxiliaries does not vary in direct proportion to the load on the main unit and the flow of condensate that is heated by the auxiliary exhaust steam. At Logan, this has been worked out so that there will be neither a surplus nor deficiency of exhaust steam over a range from no load to full load, regardless of the back-pressure on the low-pressure turbines.

The point he makes that the new generating capacity will have a practically zero fuel consumption, apparently does not check with the author's statement that the performance of the new capacity will be 4000 Btu per kwhr. The figure of 4000 Btu was arrived at by dividing the thermal equivalent of a kwhr, which is approximately 3411 Btu, by the electrical and mechanical efficiency of the unit which is about 97 per cent, making the performance of the new equipment 3511 Btu. If a boiler efficiency of $87^1/_2$ per cent is obtained, the thermal performance of the superposition would be 4000 Btu. However, when it is considered that the old boiler efficiency may be on the order of 75 per cent, whereas the new boiler efficiency may be on the order of 87 per cent, it is seen that the new capacity is obtained with practically a zero fuel consumption. With such capacity costing \$80 to \$110, it is not easy to understand the present governmental interest in hydroelectric plants.

Mr. Keeth is correct in saying that the availability to be expected for the 925 F equipment is still an unknown factor and that the availabilities that have been recorded for lower temperature units must be used with judgment when applied to the higher temperature units. In addition to the installations operating at 800 F and over, that Mr. Keeth has mentioned, may be added the Deepwater Plant of the Houston Lighting and Power Company, whose two 1325-lb pressure, 350,000-lb-per-hour boilers operate at 850 deg although the turbine operates at 750 deg. Valuable operating experience has also been obtained with the 1000-deg turbine at Delray. As Mr. Keeth mentions, it is possible that longer use of high-temperature steam may adversely effect the availability factor of both superheater and turbine, and that is why performance characteristics at lower temperatures should be carefully studied before embarking on high-temperature installations.

It is true that it seems probable that slagging of the gas passes may mark the limit of continuous boiler operation and that is why particular attention was paid to this feature in the Logan turbine. Referring to Fig. 3 on page 566 of the September issue of MECHANICAL ENGINEERING, it will be seen that the first row of tubes has been widely staggered. The numerous lancing doors to be provided are not shown. Careful estimates were made of the gas and ash temperatures at all points where slagging might occur.

Mr. Keeth's remarks have particular significance in that he has been associated with one of the pioneer superpositions, the Northeast Station.

III—DESIGN TRENDS IN 500–800 LB STEAM PLANTS BY JAMES A. POWELL[12]

Mr. Powell's paper opens with a discussion of the general influences affecting present-day power-plant design, such as the demand for lower electric rates, the reduced personnel of engineering organizations and equipment manufacturers as a result of curtailment of power-plant construction during the depression, uncertainty in the electric industry as to legislation, higher steam temperatures, and trends in cost of equipment. This is followed by a consideration (for plants of the condensing type with turbine units of from 5000 to 25,000 kw operating at 3600 rpm and boiler pressures of from 500 to 800 lb gage) of turbogenerators, condensers, steam generating units, deaerating feedwater heaters, feedwater treatment, heat cycles, and pressures and temperatures. Briefly, Mr. Powell concludes: "When all factors and influences are taken into consideration, it is believed that straight condensing-cycle plants of tomorrow, in moderate size (5000 to 25,000 kw) turbine units, will be built for boiler pressures between 500 and 800 lb and superheat temperatures of from 750 to 850 F.

"It is believed that plants which have an average fuel cost and load factor, for a boiler pressure of approximately 700 lb and a superheat temperature of 825 F, will produce electrical energy on the bus bar at the lowest total cost per kilowatthour.

"Not more than three stages of feedwater heating with an economizer will give the best feedwater heating cycle, except where extremely high air preheat is necessary.

"With availability of both boiler and turbine units practically equal, one boiler unit per turbine unit should be installed in interconnected systems in plants having two units or more.

"All auxiliaries except the boiler feed pump should be motor driven, with power which is supplied from station service."

DISCUSSION BY JOHN VAN BRUNT[13]

Mr. Powell's paper is an interesting and able summary of desirable features of design of steam plants in the range of pressures and temperatures set forth in the paper. These features have the merits of conservativeness and moderate cost which will commend them to the designer.

By inference it appears that the author believes and recommends that in the near future new steam plants be built to these pressures and temperatures. From existing operating data on plants operating with 825 to 850-F steam there is little doubt that this temperature is conservative.

As is evident from the papers presented by Professor Christie and E. H. Krieg, the immediate trend is toward superposition and logically so. Superposition, however, applies only to existing plants having low-pressure units which have not outlived their economic usefulness. Superposition of high-pressure units on these plants will extend their economic life many years.

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[12] MECHANICAL ENGINEERING, September, 1936, pp. 573–576.

[13] Vice-President, Charge Engineering, Combustion Engineering Co. New York, N. Y. Mem. A.S.M.E.

The most recent superposed units are designed for 925-F steam temperature. No plant with this temperature is in operation.

After these new plants have been in operation for a period sufficient to gain experience with 925-F steam it seems probable that the author will raise both the pressure and temperature he is now recommending.

In view of the advances in steam generation in the last ten years it seems more than probable that material progress will be made in the next decade.

The author's comments on the steam-generating unit are interesting and quite in accord with the facts. Such units are truly "tailor made," cut to fit the specifications, and also in many cases to fit within an existing building and within existing columns. No one knows this better than the designer of such units.

A partial explanation of the present lower first cost of steam-generating units as compared with those of 1923 to 1930 may be the increasing size of such units in recent years.

The following table shows the influence of size on the cost, assuming the base cost per 1000 lb per hr from a 100,000 lb per hr unit at 450 and 775 F steam temperature to be unity:

Size of unit, lb per hr	Cost, per cent
200,000	0.70
300,000	0.60
400,000	0.55
500,000	0.525
750,000	0.50
1,000,000	0.485

While these figures are for 450 lb per sq in., the ratios will be about the same for higher pressures.

One of the factors in this relation is the engineering and design costs of modern units.

To design and detail a complete steam-generating unit for a capacity of 100,000 lb per hr, including boiler, furnace, water-walls, superheaters, economizers, air heaters, fuel-burning equipment, pulverizing mills, boiler casing, forced- and induced-draft fans, and ducts will require from 8000 to 10,000 drafting hours, and including supervision and engineering, will cost from $25,000 to $30,000.

The cost of design for a 300,000-lb unit will be but little more, perhaps 1000 hr, and for a unit of 1,000,000 lb may be 15,000 hr.

From the viewpoint of capital cost, therefore, the author's conclusion that one boiler should be installed per turbine is sound.

If we agree that new plants in the immediate future will be in the range of pressure and temperature suggested in this paper, we may assume that the next development will be toward higher temperatures and pressures.

Discussion by G. B. Warren[9]

Mr. Powell has presented very ably his viewpoint as to what the trend of power-plant development is apt to be, particularly for plants of 5000 to 25,000 kw. The primary conclusion is that such plants will be largely built for steam conditions of from 500 to 800 lb and superheat temperatures of from 700 to 850 F.

In general I am inclined to agree with his conclusions. One of the specific factors which will make for the use of moderate, and may even make for the use of lower temperatures and pressures in the immediate future than those mentioned by Mr. Powell on both these and somewhat larger sizes, will be the present need for additional capacity on the part of many utility companies, with the resulting insufficient time required to design and construct equipment along more advanced lines. I think, for my own part, that this is apt to be more of a determining factor than the assumption that this is the best line of action considering overall cost per kilowatt.

On the other hand, while not definitely taking issue with Mr. Powell with respect to his hesitancy to go to pressures and temperatures higher than these, I merely wish to point out, as a member of one group of turbine designers, that a great deal of study has been given to the matter of the proper turbine design, materials, and operation for higher steam conditions. Some of these developments are described in other papers at this meeting. Several commitments have already been made and we are quite confident that turbines for temperatures in excess of 850 F and up to 925 F are at such a stage of development that they can quite safely be considered for installation in new power plants without waiting "until several more years' experience is available."

I would also like to point out that a paper of this kind should be considered, as I am sure Mr. Powell intended it to be considered, as a guide to the immediate future only. At any point in the development of the power industry in the nearly 18 years that I have been associated with it, prophets who predicted a limitation in either conditions or achievements have been wrong. I am, for one, not convinced that we have reached the end of an era of development. It is, of course, inevitably true that on fuel consumption we should be approaching a condition of diminishing returns, but that does not mean that further advancements will not be made or that improved steam conditions may not even result in themselves in reduced first cost as well as somewhat improved efficiencies.

I am reminded of a criticism that A. R. Smith, now managing engineer of the turbine department of the General Electric Company, made of a paper of mine some six years ago. At that time I had prepared what I thought was a very elaborate and comprehensive paper for the Second World Power Conference at Berlin on the subject of power-plant development. In it I set forth certain trends and certain limitations. I presented it to Mr. Smith for his criticism. He read it over carefully, handed it back, and said, "Warren, it is a very good paper but, like most of those things, you won't believe it yourself six months from now." He was right; I didn't; and, of course, many of my predictions and predicted limitations or trends were quite at variance with the actual situation. And so it is apt to be in any case like this. For that reason particularly I feel that specific limitations set up with respect to probable future development should always be taken with considerable reservation.

Discussion by E. G. Bailey[5]

Mr. Powell has brought out some good points relating to steam-electric plants within the moderate size range of 5000 to 25,000 kw capacity, recommending one boiler per turbine unit, with steam at 700 lb and 825 F. The line of reasoning followed in reaching this conclusion seems sound, and no doubt many engineers will generally agree. The chances are, however, that no other engineer in a similar position to Mr. Powell's will exactly agree with his conclusion. It is customary for every organization to call for different equipment where there is a difference in the quality and cost of fuel or other factors to meet with engineering exactness the conditions which are anticipated to exist throughout the life of each plant.

The first few paragraphs of Mr. Powell's paper are most important, and it seems that the time is now ripe for some standardization of equipment for plants of the size and type covered by his paper. The extent of building and plant extension likely to take place in the next few years will burden the

engineering organizations available to lay out these plants, as well as the manufacturers who build and erect the equipment. One of the large items of expense and causes for delay in the past is making each job a subject of careful and special study of plant layout, and the manufacturer is required to make complete sets of drawings for jobs which differ only slightly in their requirements.

Many times when a plant has been laid out with the greatest of care to burn a certain coal, it is found within a short time that it is more economical to burn a coal of different characteristics or perhaps even to burn oil or gas. Would it not be better to build plants for a wider latitude of the type of fuel which can be burned in them and which are adaptable to varying load conditions that no one can anticipate with certainty?

The development within the last several years has been such that similar equipment is now installed and operating under a large variety of conditions. The trend has been definitely in the direction of making equipment to burn pulverized coal, oil, or gas interchangeably, with latitude enough in superheater design or superheat control to adapt it readily by minor changes to meet the actual conditions which one anticipates but never quite realizes, even in "tailor made" plants.

Such a standardization need not be looked upon with fear that it will stifle progress; it will make it possible to cash in on the progress which has been made over a period of time using the best developments up-to-date as a standard over a cycle of building which is about to take place. This will result in measurable economies to all concerned. After a few years of such standardized building there will be further dedevelopments which will no doubt lead to improvements so that the next cycle of building a few years hence will follow a revised standard or up-to-date model of power plants of a class of given size.

In fact there would be a definite gain by having unified plants operating under a variety of conditions. Today when every plant is designed with just enough difference presumably to meet the variations in the local requirements, the comparison of one plant with another cannot be made on a conclusive basis, while if identical plants were installed under a large number of conditions, the comparative data would be of great value in establishing improvements for the future.

Mr. Powell is to be highly commended upon the ideas he has presented, and I trust not only will his organization but others in similar positions see the advantage of mixing a little logic and economics with what has heretofore been perhaps too much pure engineering.

DISCUSSION BY SHEPPARD T. POWELL[14]

Water correction which is perfectly adequate for low-pressure boilers is wholly inadequate for boilers and turbines operated within the zone of operation under discussion, which require a "tailor made" job, as so aptly stated by Mr. Powell.

The solution of these problems is frequently difficult because of a lack of fundamental chemical and physical data. We can do no more here than to indicate such difficulties and to direct attention to their significance. Operation of high-pressure boilers under some conditions has resulted in the formation of complex silica-alumina scale, prevention of which is still difficult, owing largely to the deficiency of our knowledge of thermal conditions existing at highly elevated temperatures at tube surfaces, and to a dearth of information relating to chemical equilibria and solubility of salts at high pressures and temperatures.

During the last few years the use of deaerating chemicals for the removal of minute traces of oxygen has increased enormously, and such treatment has, in general been justified. However, there are practically no reliable data on the dissociation products of these salts under the conditions of temperature and pressure at which they are used, nor do we have reliable data to indicate the ultimate influence on their reactions of other bases or metals present in concentrated boiler-water salines. A recently conducted survey of a group of plants has demonstrated that copper is present in varying quantities in boiler waters of all these stations. The detrimental or beneficial effect of copper in such waters has not been established, but deserves critical study.

Possibly the most difficult and costly defect in station design is the failure to provide sufficiently complete feedwater treatment and auxiliary equipment to insure clean steam. The problem of turbine-blade deposits and their removal is too well known to require discussion before this group. The avoidance of these difficulties requires specific study at each plant, since the phenomena are intimately correlated to a number of factors, the relative importance of which cannot be established and allocated without detail study.

[14] Consulting Chemical Engineer, Baltimore, Md.

DISCUSSIONS BY OLLISON CRAIG[15]

The main value of Mr. Powell's paper is, as he himself points out, that electric current can be produced at less cost per kilowatthour, taking all charges into account, by the use of steam from 500 to 800 lb pressure and with a superheated temperature range from 750 to 850 F. The economic law of diminishing returns is just as fixed as the physical law of gravity. Too often in the past, too much consideration has been given to efficiency of production and not sufficient consideration to cost of production. Efficiency of production is desirable, providing, at the same time, it reduces cost of production. By using higher pressures and higher temperatures than those indicated by Mr. Powell, higher efficiency of electrical production can be obtained or a kilowatthour can be produced for a fewer number of Btu in fuel. It does not follow, however, that the cost of electric current in dollars per kilowatthour would also be less. As a matter of fact, Mr. Powell has indicated that this cost would actually be greater.

There is only one detail in Mr. Powell's paper to which I can take exception; that is, in connection with preheated air with pulverized-fuel firing. It is true that heat is necessary and desirable for drying fuel when pulverizing wet fuel. However, pulverized-fuel equipment can be obtained with which it is not necessary to temper air from an air heater, and with which it is possible to obtain sufficient heat in the pulverizer for drying even though no air heater is used. This leaves the designer free to arrange air-heater or economizer surface or both to the most economic advantage without the necessity of giving consideration to the requirements of the pulverizer for hot air.

CLOSURE BY MR. POWELL

To judge from the written and open discussion, I seem to have conveyed the impression that I was suggesting the use of 500 to 800-lb pressure as a standard range for all types of plants. On the contrary, the fact is that I was requested to prepare a paper on 500 to 800-lb plants as distinct from other types. I, therefore, confined my discussion to these pressures, except for some very general remarks referring to higher pressures, knowing that papers on higher pressure plants were being submitted by other authors. It is recognized that pressures and temperatures higher than those indicated in my paper will be used, where economic conditions justify them.

The lack of interest on the part of some turbine manufacturers

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toward encouraging even an approach to the standardization of operating characteristics for moderate size units, is surprising, particularly in view of the fact that these manufacturers would profit most by so doing, through quicker deliveries and greater productivity of existing shops. Any step taken by them in the way of standardization would stimulate other manufacturers to do likewise to the obvious advantage of all.

OPERATING EXPERIENCES IN A SUGAR-REFINERY STEAM PLANT, BY DANIEL GUTLEBEN[16]

Mr. Gutleben's paper is a frank discussion of the experiences encountered in installing and operating two 250,000-lb-per-hr boilers at 400 lb. These are compounded upon an existing plant whose boilers were retained for reserve. The refinery in which the installation was made was kept in production during the changes. The description of the new equipment is accompanied with diagrams of the plant process and the new power plant. A feature of the plant is a steam accumulator 60 ft long which weighs 700 tons when loaded, experiences with which are described. A table gives the items of cost in the new installation and another the cost of producing steam. The feedwater control is described and illustrated diagrammatically and a typical record of steam demand and production is presented. A description of the feedwater treatment is included.

A discussion of the feedwater-conditioning features of Mr. Gutleben's paper follows:

DISCUSSION BY C. E. JOOS[17]

One of the interesting phases of plant operation is the water conditioning system in which Mr. Gutleben has taken advantage of the newly developed method of water softening primarily adapted to soft waters. The Delaware River water at the plant intake is relatively soft but, at times, contains considerable suspended matter. Because of the character of this water, advantage was taken of the phosphate method of softening, reducing the calcium and magnesium salts to what is generally known as zero hardness.

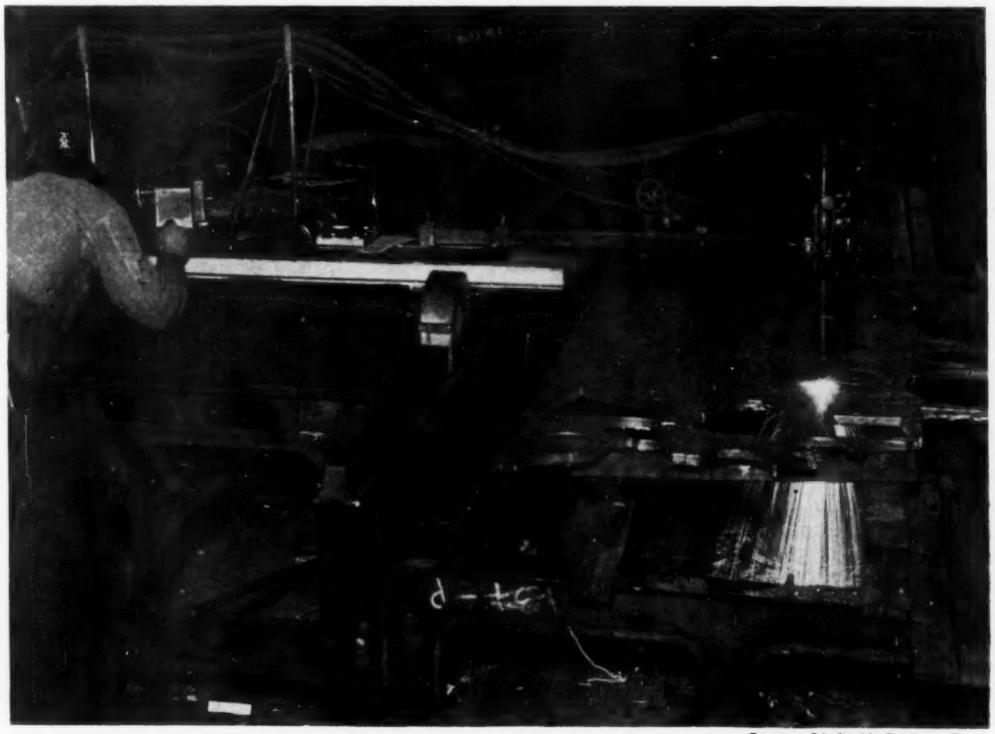
This method of water treatment has been found satisfactory, and since operating technique has been perfected at the Pennsylvania Sugar Co., many other high-pressure plants have gone to this form of treatment. At the present time approximately a score of plants utilize this method of water softening, most of which are operating with 100 per cent make-up, with boiler pressures from 600 to 900 lb per sq in.

The method followed at the Pennsylvania Sugar Co. is satisfactory, not only for naturally soft waters but also waters that have previously been given lime and soda treatment, either in the hot or cold state. Installations are now in service and others will shortly be placed in service in which the first stage is a cold-process softener, utilizing lime and soda ash for precipitating most of the hardness because of the low cost of treatment with these chemicals. The remaining hardness is precipitated by phosphate in a hot-process water softener, forming the second stage.

The pioneering done by Mr. Gutleben on his 400-lb plant has resulted in adopting the same type of treatment for higher working pressures in other plants (700 and 800 lb) and with 100 per cent success. In fact, plants in the higher pressure class, for which evaporators alone were previously considered suitable, can be advantageously handled by similar equipment.

Mr. Gutleben is to be commended for his achievements in the development of this new method of water conditioning. His efforts are conclusive proof of the invaluable service plant engineers render in the development of processes and machinery.

[16] MECHANICAL ENGINEERING, September, 1936, pp. 577–584.
[17] Water Conditioning Dept., Cochrane Corp., Philadelphia, Pa.



Courtesy Linde Air Products Co.

SHAPE-CUTTING STEEL PLATE WITH AN OXYACETYLENE TORCH

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Entropy in Strange Places

HARPERS MAGAZINE

FEW scientific concepts have proved as fascinating as the principle of the degradation of energy, familiar to every engineer as the Second Law of Thermodynamics and evaluated by him in terms of entropy. Henry Adams seized upon it in his "Degradation of the Democratic Dogma." Josiah Royce, professor of philosophy at Harvard a generation ago, discussed it with his colleagues in the departments of science and devoted a chapter to it in his "Spirit of Modern Philosophy." Jan Smuts developed a system he called "holistic" based on it in a presidential address delivered several years ago before the British Association for the Advancement of Science.

These are but a few of many instances of the stimulation to the thoughts of men primarily not concerned with the physical sciences that resulted from the contribution of that great physicist, Lord Kelvin. Aside from the theory of evolution few concepts of the last century have produced such profound effects on philosophical and religious thought as this apparently universal principle. To its credit let it be said that it has been effective in a closer understanding between two groups of men with different interests and patterns of thought, the philosopher (and the mystic) and the engineer.

A recent example of the fascination inspired by this principle that is so useful in engineering is to be found in the December, 1936, issue of *Harpers Magazine* in an article "Why Things Grow Old," by Roy Helton, essayist and novelist. Starting with the happy discovery of the one-way characteristic of time—"time's arrow" Eddington called it—Mr. Helton recalls many examples of irreversibility that have been so succinctly epitomized in the nursery rhyme about Humpty Dumpty. Growth and decay—inevitable decay—concern him.

Life concentrates, he says, in an energy-diffusing universe. Every living thing grows to a point of maximum power for such concentration, and then begins to scatter its energies again and at last surrenders to the universal process. In the end specialization goes too far. The cells no longer cooperate for the general welfare, and he quotes Chacot who made a detailed medical study of old age many years ago: "The organs seem, as it were, to become independent of one another."

Thus he decides that every living thing wages two battles. One with the general diffusion of energy to which the concentration of life is a challenge, and one with time itself which operates by the scattering of life's energy into parts of the living thing. And to give point to these thoughts he says, "How can we fight that diffusion and degradation called time in the specific cases of (1) the government of the United States, (2) the emotion of love, and (3) the individual human being?" three cases in which every one has an enormous personal stake and for which partial solutions are suggested.

The engineering student will be likely to invoke Maxwell's demon. And this is what Mr. Helton does in the form of a purposeful intelligence that will direct the fight against diffusion or specialization, just as that creature of Maxwell's imagination contrived to let all fast-moving molecules pass the trap door in one direction and the slow ones in the other.

Growing old, the author concludes, is a diffusion of energy which in living things, and apparently in those feelings and institutions into which men transform their life energy, takes a special form and follows a typical pattern. This process will not retrace itself for us, and though that fact is hard to accept, it does give us an advantage in our fight against time. For it compels us to realize that what is here and now is what we have to fight for. Not what is past, lost, or resigned.

Responsibility in Research

SCIENTIFIC MONTHLY

WRITING on "Science in an American Program for Social Progress" in the January, 1937, issue of the *Scientific Monthly*, Karl T. Compton, member, A.S.M.E., president of the Massachusetts Institute of Technology, says that no informed person will deny that our natural health, prosperity, and happiness depend upon science for their maintenance and future development. We have reached the point, he asserts, beyond which further increase in our wealth, population, physical comfort, and cultural opportunity will depend not on discovering new resources by geographical exploration but by wiser use of the resources that we now have by scientific exploration.

Practically all scientific work in the United States is carried on under one or another of three auspices—the government, industrial organizations, and educational institutions or similar altruistic foundations.

In a democracy like ours, designed to safeguard personal liberty and to stimulate individual initiative within the framework of "general welfare," there is no need for the government to embark upon comprehensive programs in pure science, invention, or industrial development. There are, however, numerous scientific services of such wide scope and universal utility that no agency except the government is competent adequately to handle them. (In this category are public health, weather forecasting, topographic mapping, development of scientific and technical standards, mineral surveys and statistics, safety codes, patents, soil science, improvement of crops and livestock.) There are other scientific services which are essentially supplementary to nonscientific governmental activities. (Among these are engineering work relating to flood control, water supply, and aids to navigation; scientific aids to national defense; development of standards for the purchasing of supplies for use of governmental bureaus.) There are also fields of scientific or technical development which hold evident promise of benefiting the public but which are not proper or practical fields for private initiative (such as the activities of the National Advisory Committee for

Aeronautics, and the financial aid to land-grant colleges for development of agriculture and engineering arts). In these three categories and in this order of importance lie the proper scientific activities of the government.

The first governmental scientific bureaus to be established had to concern themselves but little with the coordination of their programs. Side by side with the growth in the number of bureaus and in the multiplicity of their functions, however, there should have been applied (more rigorously) the principle of coordination of related work, no matter in what bureaus the work may be done.

Freedom of scientific work from political or policy-making influences is a prime consideration. Bureaus should be free to produce results that are not discolored by the opinions and snap judgments of policy-making political groups who may wish to put the dignity of "science" behind their plans in order to win public approval.

Over and above the work of particular scientific bureaus, there is increasing activity on the part of the government in undertaking large projects whose feasibility or justification are matters for technical decision from many points of view: scientific, economic, humanitarian. For technical advice on such questions, Congress and the Executive Departments should have ready access to, and should use, the best talent available both within and outside of the government services.

Considerations like these led the Science Advisory Board to recommend to the President the permanent establishment of a scientific advisory council, its members to be nominated by the National Academy of Sciences, to serve without pay, but with provision for necessary travel and secretarial expenses. This council would be enabled to appoint subcommittees on the principal scientific bureaus. The duties of this group would consist, first, in assisting the bureau chiefs to formulate general programs and policies; second, in promoting coordination and working against improper duplication of effort of the various bureaus; third, in interpreting, criticizing, or defending the work and plans of the bureaus before the responsible department secretaries and congressional committees; fourth, in giving to the director of the budget its critical and independent judgment (advisory only), regarding budgets and requests for appropriations for scientific work in the non-military departments.

Turning now to industry, we have no difficulty in defining its proper score of scientific research: That type of research is justified which shows reasonable promise of producing better products or desirable new products which can be made and sold with profit or of reducing the cost of existing products.

In any attempt to make science more effective in industry and through it more helpful to the public, certain obstacles must be met and overcome.

First is the so-called "hard-headed practical business man;" a man without vision, imagination, or enthusiasm for new things; a man who scoffs at theory or a college degree; a man whose sole criterion of proper practice is that which he has been accustomed to in the past; a man who spends as little as he can on research in order that his profits day by day may be larger.

In this same class is that type of control, sometimes exercised by a financial group, which focuses attention on the profits of the current year to practical exclusion of developing strength for the future.

From these two examples, President Compton states, "you may infer that I advocate the growing tendency to give technically trained men an increasing share in the management and policy-making activities of industry—and I do not mean to infer that financially trained men are not also essential."

A second obstacle is the cost, delay, and uncertainty in the operation of our outmoded patent procedures. This is one of the major hindrances to the development of new industries and the supplying of new employment through the results of science.

A third obstacle is found in the increasing regulatory activities of the government for the stated objective of protecting the public, but sometimes in the nature of disastrous boomerangs. A fundamental difficulty appears to reside in the fact that in general we are governed by politicians rather than by statesmen.

In educational institutions, science has no limitations in search for truth except those imposed by availability of ideas, workers, facilities, and funds. Such institutions have always been the places where the great bulk of new discoveries are made and ideas born, and this will continue to be so, since there exist no other organizations where such studies can be similarly pursued.

A great university or engineering school already possesses, because of its teaching responsibilities, the principal overhead of staff, facilities, and administrative organization necessary for a large research program, so that relatively large returns in the fields of research and development can be secured with relatively little additional financial support. It is in this direction that there lies the greatest opportunity for increased contributions to public welfare through science in the leading educational institutions, and thus far the surface has only been scratched. With more adequate financial support, a new order of institutional public service will be possible.

Magnifying 5000 Diameters

BELL LABORATORIES RECORD

FOR THE making of photomicrographs for metallographic study a microscope of exceptional power has been developed by the Zeiss Works at Jena in conference with F. F. Lucas who describes the new instrument in the *Bell Laboratories Record* for December, 1936. This metallographic microscope gives excellent definition at 5000 diameters and has an ultimate limit of 7000 diameters.

In preliminary investigations leading up to the construction of the instrument it was found that high resolution was most effectively secured by using a low-power projection lens with a photographic plate a long way from the lens system, rather than a high-power projecting lens and a short bellows. This required an extensive system of bars and couplings to keep the plate rigid with respect to the lens, and led to the use of a horizontal mounting. Microscope and camera were mounted on an insulated stand, with the camera in four sections to accommodate bellows of different lengths.

The optical system of the metallographic microscope is shown in Fig. 1. Light from a source at the side passes through a lens system, is reflected on to the specimen, and thence backward through the glass reflector to the camera.

The front lens of the microscope is set within less than a millimeter of the specimen and the space between is filled with a drop of monochlornaphthalene, as this type of objective increases the light-gathering power and resolution.

Two illuminators mounted on separate floor stands are provided, one equipped with carbon-arc and mercury-vapor lamps and the other with a spark generator. The arc lamp is the most intense source available and is generally used with filters to limit the frequency band. The mercury-vapor lamp gives

approximately monochromatic light when suitably filtered. With the spark illuminator a prism is used to spread the light into a spectrum from which a single wave length can be utilized.

Focusing the specimen where high magnifications are involved is said to be complicated.

A series of photomicrographs of different magnifications is presented to illustrate the usefulness of the new instrument in studying metal structure. Comparisons of magnifications at 200, 1000, 4000, and 6500 diameters are shown. Another set of two (1000 and 4000 diameters) shows how much more clearly fine structural details may be seen at the higher magnification.

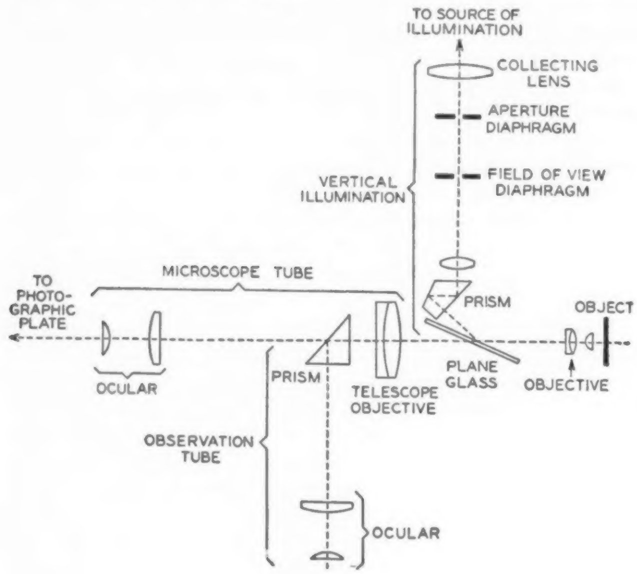

FIG. 1

Commercial Aviation in Britain

IMPERIAL AIRWAYS LIMITED, REPORT

IN HIS annual report to the members of the company Sir Eric Geddes, chairman of the Imperial Airways Limited, presented some figures on present operations and future plans.

The company, with its associates, operates airways in the British Empire and Europe, and reported increases in frequency of service and in passengers and mail carried. The average distance flown per passenger on the Empire services was 2025 miles. During the year the company and its subsidiary and associates flew 6,500,000 miles, the flying average today being 20,000 miles per day. While last year's report showed a total of 42 aircraft having a total horsepower of 55,620, the 1936 report shows a total of 76 (operating and under construction) with an aggregate of 171,030 hp.

It was reported that the British government had decided to entrust to the company the development of an air service over the North Atlantic. A new operating company is to be formed. As soon as necessary ground wireless stations and meteorological services are ready, the company will carry out some experimental Atlantic flights.

Permission from the United States government for the establishment of a Bermuda-New York service is expected shortly. The airport at Bermuda is ready and the flying boat completed. The service is being established in cooperation with Pan-American Airways.

Diagrammatic illustrations of the "Ensign" air liner and the "Empire" class of flying boat are included in the report. The "Ensign" has a length of 114 ft, height of 18 ft, top speed of 200 mph, span of 127 ft, and weighs fully loaded 20 tons. It carries a crew of four and has accommodations on the Empire routes of 27 passengers on day stages and 20 on night journeys. On European routes the liner will accommodate 40 passengers and a crew of five.

The "Empire" class of flying boat has a length of 88 ft, a height from water line of 24 ft, a speed of 199.5 mph, and a span of 114 ft. Fully loaded it weighs nearly 18 tons. With a crew of five it has accommodations for 24 passengers on day stages and 16 on night journeys.

Recovery of CO_2 From Flue Gas

AMERICAN CHEMICAL SOCIETY

SMALL laboratory models which will control the design of towers as high as 90 feet have been constructed in the Sterling Chemistry Laboratory of Yale University, to carry out the recovery from flue gases of carbon dioxide.

The work was described in a paper by Prof. Barnett F. Dodge and Charles S. Comstock, of Yale University, before the symposium on Absorption and Extraction held at Columbia University, December 28 and 29, 1936, under the auspices of the Division of Industrial and Engineering Chemistry of the American Chemical Society.

One of the commonest methods of removing carbon dioxide from other gases is to bring the gas mixture into contact with some liquid that will absorb the carbon dioxide in preference to the other gases present. This is commonly brought about in what is known as a packed tower. This is a tower filled with either a broken material or a large number of special shapes over which the liquid absorbent is caused to trickle as the gas flows in the opposite direction. In this way a large surface of contact is offered.

A solution of soda ash or of potash is commonly used as an absorbing liquid. These solutions have the property of taking up carbon dioxide at one temperature and giving it off again at a higher temperature. The latter feature is important since the carbon dioxide must be recovered from the absorbent if it is to be utilized.

In the design of a tower to carry out the absorption economically there are a number of variables which have to be considered. For example, one can vary the strength of the solution, the rate of flow of both the gas and the liquid, the composition of the carbonated liquor, and the temperature. All of these will affect the design of the tower and to make an intelligent design one must have some quantitative data on the effect of these factors.

In the past towers have been designed largely on a cut-and-try basis. The paper by the authors is the result of an endeavor to put the design of such towers on a more scientific basis. The effects of the most important factors were studied in a small tower only 3 in. in diameter packed with very small glass rings. It has been possible to interpret the laboratory results so as to make them applicable to the design of large-scale towers.

The chief findings may be summarized as follows: (1) An increase in the liquor flow rate will increase the rate of absorption and thus reduce the size of tower; (2) increase in temperature from that of the atmosphere will at first increase the rate of absorption until an optimum temperature of about

55 C is reached, after which any further increase will result in a lower absorption rate; (3) carbonate solutions are shown to be not well suited for the complete removal of carbon dioxide from gases; (4) the rate of gas flow has no effect on the specific rate of absorption, other things being equal.

As the result of these data, it is believed that the designer of such absorption towers will be able to predict better the necessary conditions for best operation.

Stack-Cutting Plate Material

INTERNATIONAL ACETYLENE ASSOCIATION

AT THE 37th annual convention of the International Acetylene Association, held at St. Louis, Mo., Nov. 18 to 20, 1936, B. F. Orr, superintendent of car shops, Cleveland, Cincinnati, Chicago, and St. Louis R.R., Beach Grove, Ind., read a paper on "Stack-Cutting Plate Material for Manufacture of Steel Parts Required for Heavy Repairs to Steel Freight Cars," in which he described methods used in the railroad's shops.

Stack-cutting means the cutting, by the oxyacetylene process, of sheets or plates stacked upon one another to a definitely determined height. The cutting torch is automatically guided by means of full-sized templates, the guiding member of which is an aluminum rail suitably fixed to a base. Considerable thought and study were devoted to the development of a template base which would meet the requirements of both strength and lightness. The material selected is $^3/_8$-in. plywood properly reinforced by $^3/_8 \times 1^1/_2$-in. strips attached to the under side with wood screws. When in use the templates are bolted to the top of the cutting-machine table and only the original adjustment is required as the templates are positioned with relation to permanently located jigs and stops. A change from one operation to another consumes but a short time as the templates can be exchanged without further adjustment.

The stacks of sheets or plates are supported by jigs mounted upon channel-section beams extending the full length of the machine which are supported in turn upon the work supports furnished with the cutting machine. The supporting jigs are constructed of $^3/_8 \times 3$-in. steel bars in skeleton form, the outline being slightly smaller than the contour of the part to be cut. The outline of the jig is within the limits of the finished contour to provide clearance for the cutting stream and the slag of the oxyacetylene cutting reaction. The material is placed upon these jigs by a labor gang and removable stop keys are provided to locate each stack of material without any adjustment after it has been piled.

The sheets are loaded one at a time in order that a visual inspection of the surface condition may be made, the surface can be cleaned and any matter which might prevent bringing the sheets in close contact for the cutting operation can be removed. The sheets are loaded twelve high where material $^1/_4$ in. thick is used, the stack thickness being nominally 3 in.

The material is loaded progressively, that is, the jigs are filled starting at one end of the machine and proceeding to the jig at the opposite end. The loading of the jigs continues, as does the unloading of them, while the cutting operation is being performed and the entire operation becomes a complete cycle of loading, cutting, and unloading. It might appear that due to the heat of the cutting reaction the edges of the sheets might become fused together, but this action does not occur under any condition.

The cut is started at the edge of the stack against the gaging stops and, if continuous, is not interrupted until the cut is completed. In cases where the lines of cut intersect and stop at the point of intersection, gates or switches are provided in the templates and when the cut reaches the point of intersection the cut is stopped until the gate can be moved into the proper position. The cut is then resumed by starting through the kerf at the point of intersection of the two lines of cut.

The results obtained through the use of the oxyacetylene cutting process in stack cutting of freight-car parts have fully met the expectations. Cost records show an average saving over a 14-day period of 16 per cent in the direct cost as against doing this work by shearing methods.

In stack cutting a large saving or earning is obtained from the recovery of new usable material. The material removed from recesses by the oxyacetylene cutting process is in one piece and of such size as can be used for the manufacture of other parts.

When the sheets are cut in stacks by the cutting machine, all pieces are identical in contour and this contour can be duplicated. It is only necessary to adjust the gaging stops on the pressing dies once. The edges of the sheets are square and full with no burrs or slivers. There is a total absence of tearing due to the fact that the cutting operation leaves no sharp corners which have high stress concentrations and yield under the additional bending stress of the pressing dies. The radii left at such locations in the sheet contour tend to strengthen this section and provide additional material for the drawing action of the die.

Eliminating Sulphur From Flue Gas

AMERICAN CHEMICAL SOCIETY

AIR POLLUTION caused by sulphur fumes and other acidic materials emitted from power-plant chimneys is yielding to a new engineering technique, Prof. H. F. Johnstone and A. D. Singh, of the University of Illinois, said in a paper read at the American Chemical Society Symposium on Absorption and Extraction, Columbia University, December 29, 1936.

A million and a half cubic feet of hot dust-laden gas per minute can be treated by "scrubbers" containing a solvent which removes by absorption 98 per cent of the sulphur dioxide from gases harboring only 0.2 to 0.3 per cent by volume.

Stack gases from boiler furnaces were studied by the authors in a cooperative investigation by the Engineering Experiment Station of the University of Illinois and the Utilities Research Commission of Chicago.

From an engineering standpoint there are three main parts to the problem of sulphur elimination: (1) The correct design of scrubbers; (2) the development of a suitable solvent for absorbing the sulphur compounds; and (3) the handling and disposal of large quantities of product consisting of elemental sulphur, liquid sulphur dioxide, sulphuric acid, and other compounds.

The treatment of such large quantities of gases to remove a relatively dilute constituent is a new and unique engineering problem. In the chemical industry, the largest scrubber handle volumes of gases of the order of a million cubic feet per hour. Examples of this operation are to be found in the recovery of gasoline from natural gas and in the purification of manufactured gas.

The treatment of stack gases to remove a very dilute constituent, however, is a different problem. The quantity of gas may readily exceed a million cubic feet per minute and because of the small concentrations involved the rate of absorption is none too great.

Furthermore, the elimination of sulphur compounds must be accomplished without interfering with the normal operation of the power station. Unless the scrubber is properly designed, it will be highly inefficient and its bulk out of proportion to the job it is doing. Finally, the operating costs which include power for fans and pumps will be excessive if the draft loss through the scrubber is appreciable and if the quantity of solvent required for wetting the surface is excessive.

The paper discussed the results obtained in a study of various types of surfaces suitable for handling these gases. The general conclusion is that a grid-type scrubber is most efficient. Scrubbers of this type are built up of small wooden laths spaced at proper intervals. They operate at a maximum scrubbing efficiency with a minimum power consumption.

Tests made in a small, experimental plant operated at the University of Illinois have shown that the scrubber need be only slightly larger in diameter than the stack itself and only 15 to 20 ft high to accomplish the removal of 99 per cent of the sulphur compounds from the combustion gases.

Large Open-Jet Wind Tunnel

ENGINEERING

AT THE Deutsche Versuchsanstalt für Luftfahrt, a large open-jet wind tunnel has been erected at Berlin-Adlershof, a description of which appears in *Engineering* for Dec. 18, 1936.

Fig. 2 shows a plan view of the tunnel. The open jet is of elliptical section with a horizontal axis of 23 ft and a vertical axis of 16 ft 5 in., but the section can be enlarged to 26 ft 3 in. by 19 ft 3 in., thus accommodating models with a wing span up to 14 ft 9 in., as well as fuselages complete with radiators and engines.

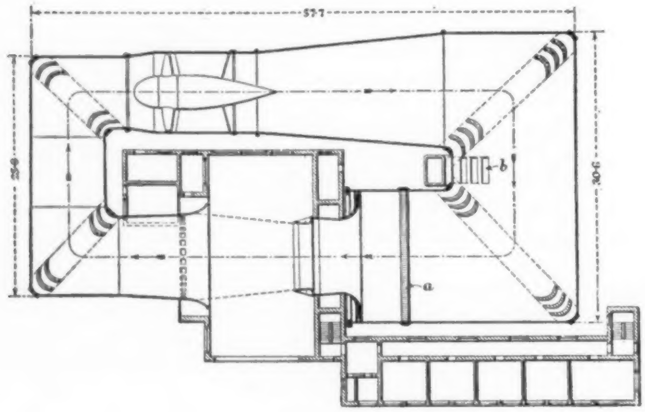

FIG. 2

The closed circuit through which the air is circulated is rectangular in plan with an overall length of 189 ft and is 84 ft wide at one end and 100 ft 6 in. wide at the other. It is constructed of reinforced concrete and is partly circular and partly elliptical in cross section. At each corner a series of vertical reinforced-concrete guide blades of airfoil section prevents the formation of eddies. Just before the air reaches the discharge nozzle it passes through a multitubular grid *a* composed of 9000 circular tubes $4^3/_4$ in. in diameter and $31^1/_2$ in. long. The nozzle opens into the test room, and after passing over the nozzle, which is suspended from a balance in the room, passes into a mouthpiece, returning through this to the closed circuit.

The eight-bladed airscrew is 27 ft 11 in. in diameter and is driven by a 2700-hp three-phase squirrel-cage motor of the pole-changing type which operates at 125 or 250 rpm. The maximum speed of the air at the outlet nozzle is 155 mph, and this speed may be varied by adjusting the pitch of the propeller blades. Air in circulation is kept pure and cool by withdrawing it through slots *b* and discharging it to the atmosphere.

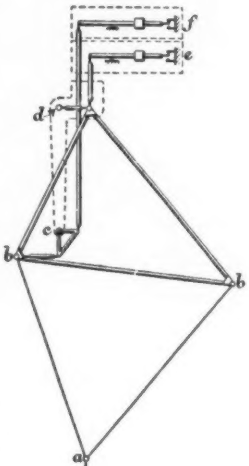

FIG. 3

Forces and moments on the model are measured on six-component aerodynamic balances of the steelyard type mounted on the floor of a measuring room above the test room. The model is suspended from the balances by six streamlined wires.

Two balances used for measuring lift and drag are illustrated diagrammatically in Fig. 3. The universal joint *a* on the model is connected by two wires to the points *b b* of a triangular framework. Vertical forces are transmitted directly to, and measured by, the balance *e*, any longitudinal movement of the frame being prevented by a link connected to a fixed point *d*. Drag forces are transmitted to and measured by the balance *f*, through a bell crank pivoted at a fixed point *c*. Balance is effected automatically, the poise being moved along the steelyard electrically. Balances are capable of handling loads up to 1323 lb.

Water Hammer in Pipes

INSTITUTION OF MECHANICAL ENGINEERS

IN A paper before the Institution of Mechanical Engineers (Great Britain), entitled "Water Hammer in Pipes, including those supplied by centrifugal pumps: graphical treatment," Robert W. Angus, member A.S.M.E., summarizes his views as follows:

The damage done to pipes as a result of water hammer is so serious that no engineer can afford to neglect it in the design of long pipes, particularly those under low heads. Unfortunately, the problem has appeared to many to be very intricate, and indeed the mathematical treatment is so involved and so lengthy that few practicing engineers would attempt to solve water-hammer problems mathematically. In many cases a purely arbitrary rule has been employed in finding the pressure rise, with little knowledge on the part of the engineer as to whether the formula fits his case or not, and thus much money may be wasted on too heavy a line, or, on the other hand, it may be so light as to be dangerous.

In the treatment of the subject given by Professor Angus in his paper the rigid theory has first been explained and some problems have been solved, but most of the paper deals with the elastic (and correct) theory. A problem is first worked out by the arithmetical integration method in order to estab-

lish ideas and to make the subsequent argument clear. The fundamental equations giving rise to Allievi's equations must be clearly understood for a grasp of the true relationships that exist, and these have been treated in some detail, but it is safe to say that if the argument has been followed up to the end of the general equations, no difficulty will be experienced with the graphical treatment.

In explaining the diagrams, very simple cases are first dealt with and the elegance of the method will make an appeal at once. The water-hammer pressure can be found for any simple pipe, and at any point on the pipe, and for any chosen gate movement, and results can be obtained with accuracy in less than thirty minutes in simple cases. For compound pipes, the solutions are nearly as rapid. The pressures arising in the discharge lines from pumps have been fully discussed in the case of pumps with small inertia, and also in cases in which the inertia is large enough for consideration, when an existing pump has been employed to supply the data used.

The accuracy of the method is said to be beyond question; where intersections are at small angles the exact points are hard to determine, but this trouble may easily be avoided by changing the scales. If a slide rule is used in solving the problem mathematically the corresponding case will be encountered.

Solvent Extraction Refining

AMERICAN CHEMICAL SOCIETY

IN A PAPER on "Reflux in Solvent Extraction," before a symposium on absorption sponsored by the Division of Industrial and Engineering Chemistry of the American Chemical Society, Columbia University, December 28, Dr. John N. Poole, petroleum technologist of New York, said "there can be little doubt that solvent extraction refining represents the greatest advance of all time in the technology of petroleum lubricants."

The technology involved, he explained, consists of mixing with raw lubricating oil a quantity of a liquid which is capable of dissolving within itself those constituents of the oil which cause it to lose body rapidly as temperature is increased. Undesirable sulphur compounds and substances which tend to form sludge or deposit carbon are also dissolved by the solvent. The desirable constituents of the oil are dissolved to a less degree.

With certain lubricants the loss of the good oil thus dissolved might be so serious that the eventual yield of premium lubricants would be commercially unprofitable. Such losses, however, can be minimized and controlled so that the high-grade oil which would otherwise be discarded with the "extract" can be forced out of the solvent, or "refluxed" back, into the refining system.

The ultimate result of these steps is to permit the commercial production of greatly improved lubricants from abundant sources and to cheapen the cost of superior lubricants regardless of their source. To the user of lubricants, Doctor Poole said, the significance is that the petroleum industry can now supply at a reasonable price lubricants which will save users many dollars each year in decreased costs of repairs and maintenance.

In the same symposium Prof. Merrell R. Fenske and Dr. K. A. Varteressian, of Pennsylvania State College, described how in fractional extraction the constituents of petroleum when "washed" with liquid solvents separate because of the different solubilities and how the process was applied to the refining of hydrocarbon fuels.

The authors claim that results of their experiments clearly set forth the increased suitability and efficiency of fractional extraction as compared to fractional distillation in which separation of constituents depends upon differences in boiling points. The work has been related specifically to a particular hydrocarbon mixture which is likely to occur in most petroleums or most gasolines—methylcyclohexane and normal heptane. However, they say that from a study of the results obtained on this mixture it will undoubtedly be possible to realize more clearly and apply the same basic principles to many other problems of petroleum refining, which will ultimately lead to still better fuels and lubricants.

It was found that when the two hydrocarbons with which the authors experimented are brought in contact with a solvent such as aniline they have somewhat different solubilities. The exact quantitative solubility relationships have been determined. From these fundamental data it is possible to conceive necessary engineering operations and equipment to carry out the ideas and principles of fractional extraction in each case analogous to fractional distillation.

Methylcyclohexane and heptane, even though they have quite widely different chemical properties as well as different properties from a fuel standpoint, particularly their knock characteristics, have boiling points not far apart. So close are their boiling points, or so identical are their vapor pressures, that in an ordinary distillation it is practically impossible to perceive that they have been separated in any degree from each other. It takes 100 or more distillations to separate these two hydrocarbons. Separation by fractional extraction requires only about ten extractions.

The manner of separating these two hydrocarbons is of considerable academic interest from the standpoint of what is petroleum and what is the composition of gasoline. It is also becoming of increasing importance from a practical viewpoint. This is because the petroleum industry is constantly seeking new and better fuels which will give better performance in not only the ordinary motor car but more particularly in powerful aviation engines.

To make these new fuels the refiner now knows that molecular structure or the molecular type is of basic importance. That is, it is no longer a question of merely having a hydrocarbon for a fuel but particular concern is attached to the molecular structure of the hydrocarbon fuel. The pronounced effect of molecular structure on octane number is illustrated by the fact that the octane number of normal heptane is zero while that of methylcyclohexane is about 75.

Use of Perilla Oil Increasing

INDUSTRIAL BULLETIN

ACCORDING to the *Industrial Bulletin* of Arthur D. Little, Inc., for December, 1936, 150,000,000 lb of perilla oil were imported into the United States from Japan in 1936. This oil has been found to be of great value in making soyabean oil useful for paints, varnishes, and linoleum by increasing its drying speed. The mixture of the two oils incorporates the cheapness, pale color, and long-lived flexibility of the soya oil with the quick-drying action of the perilla, and, in varnish cooking, the quick-bodying of the perilla oil as well.

Perilla oil, says the ***Bulletin***, is produced from the tiny seeds

of a plant of the mint family, closely related to the highly colored coleus of our gardens. The plant is an annual which needs a long growing season to mature its crop of seeds, and in this country does best in the southern states. In this respect it is quite different from the quick-maturing flax plant, which produces linseed oil, the oil nearest in appearance and odor to perilla. It is hoped that harvesting machinery can be adapted to handle this crop and not lose too many of the seeds from their brittle capsules.

The Manchurian crop, most of which comes to the United States, is being rapidly increased, and this, together with our own raising, is expected to make the oil well-known fairly soon. The Japanese are as much interested in the press-cake as in the oil, and use it as fertilizer for their mulberry trees. The cake may soon find other than fertilizer uses in this country.

Perilla oil, alone, is not of much interest as a paint oil, for it yellows rather badly in the light (whereas linseed oil yellows in the dark). Further, it has to be boiled or kettle-treated, if it is to be used as a paint oil, to free it of its tendency to wander from the pigment it is intended to bind. It is in blends, particularly with soya-bean oil, that perilla achieves the balance of properties that makes it the near sensation it has become. Paints and waterproofings of good drying properties and great durability are possible with this combination of oils from Manchukuo.

Exhaust and Air-Flow Codes

AMERICAN FOUNDRYMEN'S ASSOCIATION

THE American Foundrymen's Association has recently approved and published two tentative codes of recommended practices developed by its Industrial Hygiene Codes Committee. These codes are the first two in a series of some 25 codes being developed to assist in the standardization of dust-eliminating methods and improvement of shop operating conditions in the foundry industry. The two codes which are now available are:

36-27 Tentative Code of Recommended Practices for Testing and Measuring Air Flow in Exhaust Systems. 13 pp., 12 figs.

36-28 Tentative Code of Recommended Practices for Grinding, Polishing, and Buffing Equipment Sanitation. 24 pp., 30 figs.

Code 36-27 is prepared to aid in the standardization of the general type of instruments and technique employed in determining the volume and velocity of air flow in exhaust systems. It covers the application and testing technique for pitot tubes, inclined and vertical manometer gages, revolving-vane type anemometers, and swinging-vane type direct-reading velocity meters. The figures contained in this code add greatly to the methods described.

Code 36-28 describes recommended practices for the ventilation of all grinding, polishing, buffing, scratch-brushing or abrasive cutting-off wheels, and grinding or polishing straps or belts and is very similar to the new State of Illinois Buffing and Polishing Equipment Sanitation Law. A series of definitions is followed by sections on applications for hood and branch-pipe requirements, design of exhaust systems, testing exhaust systems and hood and enclosure design, and minimum air velocity required. The illustrations will be found helpful in aiding plant engineers in designing effective equipment to meet plant requirements, especially for the smaller foundries.

Copies of these codes may be secured from the American Foundrymen's Association, 222 West Adams Street, Chicago, Illinois, at $2 per copy.

A New Transparent Plastic

INDUSTRIAL BULLETIN

FROM the *Industrial Bulletin* of Arthur D. Little, Inc., comes the following brief note on "pontalite," a new transparent plastic scheduled for early production by the ammonia department and plastics department of the du Pont Company:

Chemically this transparent organic glass is the methyl ester of methacrylic acid (more briefly methylmethacrylate). It shares the lightness of the urea-formaldehyde, vinyl, and styrol types of plastics, but far exceeds them in transparency and brilliancy. It may be molded into complex shapes or subjected to machining, drilling, and cutting. The monomer from which the plastic is made can be poured into molds and polymerized, or used to impregnate cloth, paper, or wood.

In other physical properties, pontalite exhibits an unusual combination of qualities. In addition to unique clarity, this resin has a high softening temperature, high tensile and impact strengths, good dielectric properties, low specific gravity, light stability, good ultraviolet transmission, and is unattacked by the usual inorganic reagents and some of the more common organic solvents. Although the resin is softer than glass, it is more surface-resistant than most other thermoplastics. One can readily restore original brilliance of a scratched surface by simple polishing procedure. The resin, due to its unusual clarity, can be fabricated into delicately tinted shades and combined with varying amounts of dye or pigments, and the control of opacity promises to give wide latitude in the decorative effects that may be obtained. The glass-like transparency of the resin suggests many uses as glass substitutes where strength, lightness, ultraviolet transmissibility, and ease of fabrication by molding are desired.

Machine-Made Jobs

MACHINERY AND ALLIED PRODUCTS INSTITUTE

IN THE third of its pamphlets on technology and unemployment, entitled "Machine-Made Jobs," the Machinery and Allied Products Institute, of Chicago, continues to supply facts and figures to counteract some of the misstatements and erroneous ideas popularly associated with "technological unemployment." Typical of some of the facts presented are the following:

Telephone girls increased by more than 50,000 during the ten years that the dial system was being installed, and linemen increased 100 per cent.

Ice dealers more than doubled between 1920 and 1930 because mechanical refrigerators popularized all refrigeration.

It takes far more workers to furnish the textile demands of a thousand Americans today than it did in the colonial days of spinning wheels, due to increased use of textile products as a result of lower prices when machine methods are used.

Machines have revolutionized office work in recent years, yet stenographers and typists increased 32 per cent and bookkeepers, cashiers, and accountants increased 27 per cent between the last two census years. Population increased only 16 per cent.

Sound pictures displaced 50 per cent of all theater musicians, but during the same years musicians and teachers of music increased by 35,000, actors by 17,000, theater ushers by 7000, and radio employees by 15,000.

A printer today can set more than five times as much type as one without a linotype machine did in 1890, yet there are five times as many employed in the industry as there were then because machinery has lowered prices and made possible the vast growth of the printing and publishing business.

The employment of both women and children in manufacturing industries has declined during the last generation while mechanization has been greatest, and the employment of men in manufacturing and mechanical industries has more than doubled since 1890.

Student Views on Education

TAU BETA PI QUESTIONNAIRE

WHAT the undergraduate thinks of engineering education was recently disclosed in a report issued by the engineering honor society of Tau Beta Pi giving the results of a questionnaire prepared by student members of the Society. The questionnaire was sent to 1000 undergraduate members of the Society, most of whom were seniors, and 439 answers were received. Because of the character of the Society's membership, it must be remembered that the opinions expressed are those of students with high scholastic records.

There were seven groups of questions and they covered (1) study procedure, (2) instruction procedure, (3) qualifications of instructors, (4) orientation in the professional field, (5) determination of scholastic and professional ability, (6) stimulation of professional interest, and (7) miscellaneous. Some of the opinions expressed are noted as follows:

Problems illustrating the practical application of theory are preferred. Assignments to textbook reading should be made in short assignments; texts written by the students' own instructors are not generally favored.

Informally conducted classes of less than 20 students and lectures to small groups by a recitation instructor appeal more strongly than other classroom procedures. The students do not consider laboratory work overemphasized, but they believe that elementary courses should closely follow laboratory manuals while greater independence should be given students in advanced classes.

Knowledge of subject matter on the part of the instructor is the prime qualification in the minds of the undergraduates, beyond which, in the order named, the following were listed as important: Perception of student viewpoint, careful drilling in basic principles, personality, patience, and maintenance of interest by occasional introduction of extraneous items of practical value. Good teachers are more essential in freshman year than in later periods.

Ninety per cent of those answering believe that general interest in the subject matter influenced their choice of a professional field, as well as known aptitude developed in previous experience. Neither family advice, nor that given by registration officers or teachers was considered by the majority as having influenced the choice. Seventy-five per cent selected their course before entering school; 25 per cent changed the course after entrance; and 90 per cent plan to follow the course in which they are training if opportunity permits. The value of graduate study is almost universally admitted. Professional guidance offered by the schools satisfies about half of those answering; and to improve this service it is suggested that courses in vocational guidance be given and that there be a closer intimacy between student and registration officers.

Students receiving good grades are generally respected. Comprehensive examinations receive student general approval.

The opinion that engineering teachers fail to stimulate the students' enthusaism for the profession is held by 40 per cent, while a large majority believe that professional and honorary societies should assume the responsibility of creating this interest in the profession.

Only a few (20 per cent) state that the depression has dampened their interest in engineering. As many as 60 per cent report that their schools offer an effective organized program of placement guidance.

The estimate of the value of a college education is reported as follows: Ability to think logically and with concentration, 25 per cent; professional training, 20 per cent; ability to work, 15 per cent; social training for effective participation in activities of organized society, 15 per cent; extra curriculum activities, 10 per cent; professional contacts in faculty and among classmates, 10 per cent; good times, 5 per cent.

Chief Problem of 1937

THE NATIONAL CITY BANK OF NEW YORK

A REVIEW of general business conditions presented in the January, 1937, newsletter of The National City Bank of New York opens with the statement that "1936 has closed with business at the highest level since the depression began and 1937 opens with great expectations." After a survey of current economic conditions and a discussion of commodity prices and price relationship, and unemployment, and gains in capital goods it is stated that the emergency has passed and the problem now is to get away from emergency policies back to the regular self-supporting activities of a balanced system; to put every possible available worker into a job where he will help the whole situation instead of being a burden to it.

On the other hand, the newsletter continues, the equilibrium will not maintain itself without understanding and cooperation. If the recovery in agriculture, which adds to the cost of living, is made the basis for further wage claims which result in price increases, the balance may be disturbed by a rise in industrial prices to higher levels than consumers can pay. Already there are apprehensions as to recent price advances in manufactured goods, which have not yet been tested on the ultimate consumers; and also as to the level of costs in the building industry, with both materials and wages rising. Moreover, strikes slow down recovery.

Nor is the outlook wholly secure on the side of agriculture, it is averred. There is uncertainty as to the permanence of the improvement on two counts. First, a part of the agricultural income, to be sure a smaller part than in preceding years, is derived from government payments. Second, prices have risen on the basis of short production and full crops all around might again create a disparity. Until it is demonstrated that the markets are strong enough to absorb considerably larger crops without loss of farm purchasing power, increases in prices of things the farmer buy will be hazardous.

Finally, the newsletter concludes, taking the shorter view, the commodity price rise in the past two months has been very rapid, and forward buying has been liberal. When business men decide they have bought as far ahead as advisable, the move will slow down and the pace of recovery may slacken. Such fluctuations, however, are normal in the business situation. They are not to be regarded as disturbing, as a disruption of the general equilibrium, though strikes or an excessive rise in industrial costs and prices would be.

LETTERS AND COMMENT

Brief Articles of Current Interest and Discussion of Papers in Previous Issues

Steam Rail Cars

To the Editor:

In the editorial "Recrudescence of Steam" in your December issue you state: "Although Europe has witnessed several steam rail cars, this country has not."

More than twenty years ago the Stanley Motor Carriage Co., of Newton, Mass., built several steam rail cars which were operated on railroads in New England. About 1918, the Rushmore Co., of Boston, took over the Stanley rail-car development and built a number of units, some of which were put into service in this country, while others were exported.

In 1926 the International Harvester Co. built a steam rail car, and the year following, collaborating with the Ryan Car Co., built three more units of improved design and increased power. These were put in service on the Chicago, Milwaukee, St. Paul, and Pacific Railroad. At the present time one of these units is in regular service out of Milwaukee. Detailed descriptions of these cars have appeared in *Railway Age* and other journals.

You mention the Besler steam rail car now in operation on the New York, New Haven and Hartford Railroad, and the steamotive units which are under construction for the Union Pacific. There may have been other steam rail cars built in this country, but this country has at least witnessed the foregoing, and there are *several* of them.

Earl C. Walker.[1]

The Port Washington Power Plant

To the Editor:

The Port Washington power plant, the design features and operating performance of which were described by F. L. Dornbrook in the November, 1936, issue of Mechanical Engineering, has now been in operation for one year. For those of us connected with the design of the equipment in the plant, it has been an interesting experience, particularly so because of the absence of any major difficulty. That does not mean the minor difficulties encountered have not given us very valuable information covering the operation at the high pressure and high temperature used in this power plant.

The records indicate a control of pressure and temperature remarkably close to that specified. This close control of temperatures during variation in loads is of vital importance. It will assist in maintaining a high efficiency of all the equipment, and in eliminating excessive distortion from temperature changes. This is of particular importance in the steam turbine where close clearance must be maintained in order to obtain maximum efficiency. Temperature changes may also cause excessive stresses through distortion and, since these stresses are in most cases difficult to estimate, they may exceed the safe permissible limits. Many parts exposed to high temperatures have been designed for a certain limited stress. This stress will cause a certain creep over a certain period of time. If this stress is increased by an additional stress caused by distortion, it is obvious that the rate of creep will be accelerated, reducing the life of that part of the equipment.

Steam leakage in a few of the smaller pipe joints around the turbine has been one of the minor difficulties. When this unit was designed and built a few years ago the experiences with pipe joints was not as complete as it is today. Since that time information has become available which will permit of a design where no such difficulties should occur. However, it is again emphasized that in order to reduce these difficulties pipe joints should be eliminated wherever possible.

Materials selected for the various parts in the steam-turbine construction have so far been satisfactory. Most of these materials have been used previously for the same temperature without any particular difficulty and it was expected that they also would be satisfactory in this case. However, it should be noted that no inspection of the turbine unit proper has been made up to this time, therefore, no definite statement as to the suitability of all materials can be made at this time.

The high efficiency of this power plant is the result of a careful analysis of all design features, arrangement, and selection of equipment. In addition, the maintenance of a uniform operating condition will allow the equipment to be operated at its best efficiency. Other conditions such as maintaining an efficient load factor, the skill of the operating force, and the operating cycle have all added to the efficient result.

The reheat cycle used in this plant has been used in a large number of plants. In later designs there is a tendency to discontinue this cycle, the reason being to eliminate some complications. Higher temperatures instead are now used in order to increase the efficiency. To obtain an efficiency equal to Port Washington with a nonreheat cycle requires an initial operating temperature considerably higher than that now considered safe. The reheat cycle can employ just as high temperatures as the nonreheat cycle, therefore, in view of the experience with this cycle, the economic limit does not seem to have been reached.

H. Dahlstrand.[2]

Domestic Oil Burners

To the Editor:

In the November, 1936, issue A. H. Senner[3] discussed the characteristics and performance of several types of oil burners, and showed the errors found in heat balances based on Orsat analyses. Broadly speaking, the paper should be welcomed because it might remind members of the A.S.M.E. that large numbers of small devices are using our natural fuel resources, and as a result of the reminder it should induce them to study this field for the purpose of contributing to public welfare and interest. Actually, an oil burner can be installed in the basement of a home and be nearly forgotten but, from a professional standpoint, the domestic oil burner, as a

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[2] Engineer-in-Charge, steam turbine department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Mem. A.S.M.E.

[3] "Domestic Oil Burners," by A. H. Senner, Mechanical Engineering, vol. 58, November, 1936, pp. 705–712.

consumer of fuel, is in that class of devices which should receive all of the helpful efforts that the A.S.M.E. can afford.

The author notes the high and low fire of the vaporizing pot burner and states that very few burners operate in that way despite certain advantages which are claimed. The fact is that only a vaporizing or pot burner can operate high and low. The number of such burners must necessarily be small. Tests at Mason Laboratory have shown that there is no economy gained by a high-low burner as against the on-and-off burner. This appears to be due in part to the fact that a great increase in excess air is required on the low fire to keep it from smoking. This makes for low efficiency. The claim of more even heating is not justified because the low flame must today be enough for domestic hot water only. Any greater output would put some steam in the system during the summer and this would not be tolerated.

In describing the blue-flame rotary burner the author calls it "one of our most important subdivisions of domestic oil burners....." From a commercial standpoint this may be doubted, but the burner is certainly unique. It can be adjusted over a comparatively wide range of fuel-burning with high CO_2. This may be explained in part by noting that both oil and air are thrown off the periphery of the rotor at uniformly high speed whether the amounts are large or small. The effectiveness of the mixing process is not diminished. This cannot be said of other types of burners. Also, the flame is high enough to avoid losses through the dry or nonjacketed ashpit so common among heating boilers. The distribution of the flame is such as to justify the term "wall-wiping."

While the author points out the shortcomings of the Orsat for heat-balance purposes, he concludes that in practice the Orsat is quite useful and that a CO_2 determination is enough. The blue-flame burner, however, can produce an appreciable amount of CO without smoke. Except for that fact, it is enough to get a reasonably high CO_2 without smoke. The Orsat and the eye together can accomplish the desired purpose. The real trouble is that in the field the eye is used and the Orsat is omitted.

In connection with the heat balances, it is suggested that the really unaccounted for part of the heat balance could be made to stand out more clearly by determining the heat loss of the boiler itself. A completely water-jacketed boiler would have a rather constant heat loss regardless of the kind of burner used. Furthermore, the boiler could be closed tightly and tested like a steam radiator for its heat loss. This would not be exact, but it would contribute to the accuracy which the author is seeking.

Performance curves in Figs. 9, 10, 12, 13, and 14 show, according to the author "......performance for the air-fuel ratios which would prevail in good practice for the several types of burners." Since these ratios were determined it is regretted that the author did not state them as was done in Fig. 14. It might serve in practice to prevent some of the unburned-fuel losses which were previously pointed out.

Fig. 9 verifies tests made by others as to the performance of the several types of burners. Three factors which may account for the superiority of the vertical rotary burner are (1) reduced dry-ashpit loss, (2) wall-wiping flame, and (3) complete combustion with low excess air. The arrangement of economizers shown in Fig. 11 might have provided a rough evaluation of these three items but it does not because the two heat-economizing devices were tested together. The lower economizer, being partially water-backed, would have alone indicated some of the ashpit loss. The upper economizer tested with both the rotary and gun burners would have indicated the effect of the wall-wiping flame. Since it is possible to increase the efficiency of some boilers by baffling the upper flue passages with firebrick, it would have been interesting to have tested the upper economizer both connected and disconnected in order to separate the heat-absorbing and possible effects due to baffling.

Figs. 10 and 14 both indicate that gun burners should be installed in completely water-jacketed boilers. Where only moderate amounts of heating surface are to be employed there is still some question as to how the surface should be disposed. Water-jacketed surface in the base would be shielded from the flame by refractory and might absorb less heat than the same amount of surface placed in the flue passages. Heating surface in the base would be useless with a vertical rotary burner. In fact the base would be air cooled. It is possible that reasonably good special boilers may appear with dry ashpits quite heavily insulated.

The tests here reported were all obtained under continuous operation. In actual installations these burners are on and off all day long. Thus, several heat losses go on while the burner is not operating. The extent of these losses depends upon the duration and number of "off" periods, the heat stored in the boiler and refractory material, the furnace draft, the type of oil burner, the boiler design, and even upon the type of heating system. The overall effect is to reduce the average efficiency. One boiler with a lower steady-load efficiency than another may still be more economical in practice. The foregoing items are suggested as additional to those mentioned by the author relative to the selection of burners for a specific installation.

This paper indicates that the author has the background, the experience and the means to carry on further research. Another fundamental problem in combustion is therefore suggested here for the author's consideration. New boiler designs for oil burners generally provide more heating surface, smaller flues and furnaces than coal - burning boilers. While not freely admitted, the problem of pulsations has occurred. "Pulsations" or "breathing" are terms which have been used to describe the rhythmical and sometimes severe pressure changes taking place in the boiler furnace. It has long been known in the power-burner field, and was usually stopped by increasing the furnace draft which in turn increased the supply of air. The trouble, as the remedy indicates, was commonly attributed to a lack of sufficient air.

However, this explanation does not seem to be literally true. Domestic oil burners can pulsate with 50 per cent or more of excess air. In fact, an absolute deficiency of air may sometimes stop the pulsations while an increase in excess air will practically always do so. While certain preventative measures may be adopted in boiler design, the incipient difficulty still remains. A number of collateral observations can be made which seem pertinent, but the most important one for the present purpose is the fact that the trouble occurs when the percentage of excess air has been reduced to the point required for good combustion. It would not be unreasonable to suspect that domestic oil burners as consumers of fuel may not always be doing as well as they should. It is hoped that the author will extend his combustion experiments and that the A.S.M.E. will actively encourage further research in this field in such ways as it can.

L. E. SEELEY.[4]

[4] Assistant Professor, Yale University, New Haven, Conn. Mem. A.S.M.E.

To the Editor:

The results presented by A. H. Senner in his paper[3] in the November, 1936, issue of MECHANICAL ENGINEERING are quite interesting and serve to call attention to the fact that engineers have paid too little attention to this problem of domestic heating.

One question which the author did not discuss is the size of the combustion chamber and the heat liberation. This is an important phase of domestic oil-burning as well as of all fuel-burning equipment. In my opinion, to get good combustion and give longer life to refractories, heat liberation should be limited to a reasonable amount. An enormous number of oil burners are installed in heating boilers designed for anthracite coal. Frequently there is insufficient combustion space for oil. This condition is aggravated by the fact that many contractors installing oil burners put in far too much brickwork. Thus, they cut down on combustion space which is already too small. In some of the burner units on the market, the heat liberation runs above 150,000 Btu per cu ft per hr, and in one case nearly 200,000 Btu per cu ft per hr. In my opinion this is quite excessive. This doubtless gives trouble with refractories and shortens their life. It is also one of the causes of smoke.

Another vital problem, directly related to oil burners, is the rating of heating boilers. No standard method of rating cast-iron boilers or of listing their capacity is used by the industry. Due to competition, ratings of heating boilers have been boosted repeatedly until most of them are too high. After repeated efforts, I have found it impossible to get test data from many manufacturers of this type of equipment. In many districts there are no regulations on heating or on boiler capacities. Consequently, many buildings are underradiated and boilers are too small to carry even the radiation installed. In cold weather, the boiler must be forced all the time. This results in high stack temperature and inefficient operation. Many times, it is absolutely impossible to get sufficient heat from newly installed plants. Either the plant must be revamped, or people use stoves, fireplaces and portable heaters to help out the inadequate plant.

Tests given out by boiler and oil-burner manufacturers, usually show CO_2 around 12 per cent. In practice, most oil burners are set with CO_2 at 6 to 8 per cent. I have even heard of oil-burning units where the excess air ran 200 per cent. Consequently, there was a high flue-gas temperature. The efficiency certainly was much lower than claimed or than shown on tests.

There are doubtless several hundred makes of domestic oil burners on the market. A large number are assembled. If you order a dozen burners at a time, they will put your name on them. We have found it almost impossible to get specifications and engineering data on some makes of burners. A request for a catalog brings a folder showing pictures of beautiful homes and a play room made out of the coal bin.

There is a tendency to use a standard-size nozzle with ample capacity. For instance, on small domestic units, it is almost universal practice to use a 1.65-gal nozzle. Tests shown in the paper[3] indicate this size nozzle gives more than maximum capacity for some boilers tested. Hence, they might be overfired most of the time.

There is certainly a lot of food for thought in this paper.[3] Unfortunately, many of the men selling and installing oil burners would not know what it was all about. Most oil-burner manufacturers sell their product through agents or dealers. They often sign up any one they think might sell a few burners. These may be plumbers, electricians, hardware dealers, carpenters, or men who have sold such items as ice boxes, vacuum cleaners, radios, insurance, and books. There is certainly a gross amount of ignorance among oil-burner dealers. I have talked to some who have no idea that air was required to burn oil or that a vent should be provided for a tank. In one case, the blower was installed so that it ran backward. Fuel-oil lines may be run exposed across basement floors and the cheapest kind of wire strung without conduit for electrical connections. It is not at all uncommon for dealers to install burners without measuring the radiation or determining the capacity of the boiler. In other words, they have no idea whether the burner they are installing or the boiler will carry the load. All they do is ask the prospect if he has had any trouble with his heating plant. No check is made on the chimney. Probably they wouldn't know how to use a draft gage if they had one. The average oil-burner salesman gives his prospect the idea that the installation of an oil burner will solve all his heating problems. The customer often thinks the installation is entirely automatic and all he needs to do is put oil in the tank. He seldom realizes that maintenance is necessary or even desirable.

In all large cities and even in most smaller ones, there are building codes and regulations on plumbing and electrical work. Men without any qualifications whatever are allowed to install heating plants, stokers, and oil burners. One of the greatest needs in most communities is a good heating code.

WILLIAM G. CHRISTY.[5]

TO THE EDITOR:

When the paper[3] by A. H. Senner was presented at the Annual Meeting of the A.S.M.E. on November 30, 1936, the oral discussion ensuing brought out a number of important points, one of the most important of which was: Does the type of oil burner considered adapt itself suitably to the type of boiler under which it is to be installed? Other discussion mentioned the important fact that extremely high heat release, exceeding all practical limits, may be attained in the furnace. It was also brought out that such an overload on the combustion chamber damages the refractory and greatly shortens its life. There is another point that was not mentioned and which, I believe, is equally or even more important. This is the possibility of damage to the boiler itself.

The writer limits his brief comments to the cast-iron sectional type of boiler. There are many forms of arch-type sections installed to increase effective, radiant, and convective heating surfaces. At the same time these arch sections provide more effective baffling for turbulence and mixing of the products of combustion. Boilers of this design, as a rule, are built and installed primarily for hand firing of low and medium volatile coals.

When a boiler of this type is converted into an oil-burning installation, proper selection of the burner is of extreme importance. Use of certain of the gun-type burners in this boiler may result in localized overheating of the arch section. This is commonly known as flame impingement. The combination of flame impingement and such basic factors as thick section material, possibility of internal surfaces being fouled with sludge, and the maximum temperature allowed with consideration for the characteristics of cast iron are often the cause of cracked sections. The sections are expensive, and a crack in a high-temperature zone nearly always necessitates renewal of the defective section. Intelligent study of each type of boiler and oil burner should be made, giving due

[5] Smoke Abatement Engineer, Hudson County, N. J. Mem. A.S.M.E.

consideration to the possibilities of damage to the sections by flame impingement.

Comparison of the design of the cast sectional-boiler combustion chamber with the methods used in designing many large power installations is worthy of consideration. Often, the type of combustion equipment is decided first with respect to load. The combustion space and shape is next designed also with respect to load, and with respect to the style of boiler best suited to the individual installation. It is difficult to obtain satisfactory performance when fuel-burning equipment is unintelligently installed in conjunction with a boiler and combustion chamber designed for other types of equipment.

Adaptation of cast sectional-boiler combustion chambers to various types of fuel-burning equipment is even less flexible than with other types of boilers. The furnace is usually self-contained; its dimensions are fixed by the boiler proper. At best, an installation designed for two possible combustion systems is but a compromise. The compromise, if such is the case, should be between two closely allied flame conditions.

A furnace designed with a large area of radiant-heating surface might be used satisfactorily where there is a long flame and considerable furnace turbulence, while a furnace having little radiant-heating surface exposed, and having large convective surfaces, is better suited to conditions producing a more moderate flame length and completed combustion instead of flame impingement.

HARRY M. SPRING.[6]

[6] Boiler and Mechanical Division, Mutual Boiler Insurance Company, Boston, Mass.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following are records of the interpretations of this Committee formulated at the meeting of November 20, 1936, and approved by the Council.

CASE No. 828 (REOPENED)

(Special Ruling)

Inquiry: Is it permissible, under the Unfired Pressure Vessel Code, to use nickel-clad material for fusion-welded vessels?

Reply: It is the opinion of the Committee that unfired pressure vessels may be constructed of nickel-clad plates, provided that all Code requirements covering the material of the base plates, welding, and tests for the class of service for which the vessels are intended, are complied with; the allowable pressure for the vessels is computed from the thickness of the base plates without any allowance for the nickel cladding; and such welds are completed before radiographing where this is required.

It is important that the completed weld or welds have a corrosion-resistant property substantially equal to that of the nickel cladding. Until such time as suitable rules to test corrosion-resistant properties of welds are formulated, the manufacturer should satisfy the purchaser that the weld is suitable for the intended vessel use.

CASE No. 833

(Annulled)

CASE No. 834

(Special Ruling)

Note: The Boiler Code Committee is actively working on a Case to provide for rules for the welding of unstabilized materials of similar grades.

Inquiry: Will it be permissible to apply the Code symbol stamp to unfired pressure vessels fabricated by fusion welding of chrome-nickel steel conforming to A.S.T.M. Specifications A 167-35T, grade 4, with the following limitations:

Carbon, max, per cent	0.07
Manganese, per cent	0.40-1.50
Chromium, per cent	at least 17
Nickel, per cent	at least 9.5
Tensile strength, min, lb per sq in.	75,000
Yield point, min, lb per sq in.	35,000
Elongation in 2 in., min, per cent	30

It is pointed out that this class of material has previously been recognized in Case No. 792 and in the recently issued Specifications S-33 for alloy-steel castings, S-34 for seamless alloy-steel pipe, and S-35 for alloy-steel pipe flanges.

Reply: It is the opinion of the Committee that stabilized austenitic chrome-nickel steel conforming to A.S.T.M. Specifications A 167-35T, grade 4, with the chemical limits modified as above, may be used for the construction of welded unfired pressure vessels, this steel to be stabilized with either columbium or titanium. The minimum columbium content shall be 10 times the actual carbon content with a maximum of 1 per cent; the minimum titanium content shall be 6 times the actual carbon content with a maximum of 0.60 per cent.

The rules in Par. U-68 shall apply, except modified as follows: The stress-relieving and stabilizing heat-treatment of the vessel of columbium-bearing steel shall be performed at a temperature not less than 1550 F and held at that temperature for a period of time proportioned on the basis of at least 1 hr per inch of thickness but in no case less than 2 hr, and of the vessel of titanium-bearing steel shall be performed at a temperature not less than 1550 F and not to exceed 1650 F and held at that temperature for a period of time proportioned on the basis of at least 1 hr per inch of thickness but in no case less than 4 hr. The complete vessel shall be heat-treated as a unit, no local stress relieving being permitted and it shall be allowed to cool slowly in a still atmosphere.

The welded test plates shall be made from the same lot of material as the vessel itself, they shall be heat-treated with the vessels, and, if possible, placed inside the vessel.

The free-bend test specimen, which need not be more than 6 in. in length, shall be subjected to a "susceptibility to embrittlement" test[1] as follows: The specimen shall be reheated to and held at 1200 F for 1 hr; the top and bottom surfaces of the specimen shall be ground and polished and the specimen immersed in a boiling copper-sulphate sulphuric-acid solution for a minimum

[1] This test proves the stability of the weld metal and the parent metal adjacent to the weld.

period of 48 hrs. This solution shall consist of 47 cc concentrated sulphuric acid and 13 grams of crystalline copper sulphate ($CuSO_4 . 5H_2O$) per liter of solution. After immersion the samples shall be bent as specified in Par. U-68. The elongation on the outside fibers shall not be less than 20 per cent, at which there shall be no evidence of fissuring.

Representative drillings of the weld metal shall be obtained from one of the welded test plates and the chemical analysis of the weld metal shall be within the following limits: The chromium and nickel content of the weld metal shall be within the same range as the parent metal; the columbium content of the weld metal, when columbium is used as the stabilizing element in the weld metal, shall be at least 9 times the carbon content of the weld metal and shall not exceed 1 per cent; the titanium content of the weld metal, when titanium is used as the stabilizing element of the weld metal, shall be at least 5 times the carbon content of the weld metal and shall not exceed 0.60 per cent. In case the chemical analysis of the first drillings of the weld metal fails to meet the foregoing specifications, two additional sets of drillings may be taken from the same welded test plate and the test shall be considered satisfactory if both these retest analyses meet the specifications.

The allowable stress in the design formula shall not exceed 15,000 lb per sq in., for operating temperatures up to 900 F, with a joint efficiency of 90 per cent.

CASE No. 836

(In the hands of the Committee)

CASE No. 837

(In the hands of the Committee)

Active Interpretations

SINCE the first edition of the Boiler Code in 1914, the Boiler Code Committee has issued over 800 cases or interpretations of the rules in the various sections of the Code and the different editions of each, which affect the application of these rules to boiler and pressure-vessel construction.

From time to time revisions have been made in the Code rules to incorporate the intent of some of the cases which have thus rendered these cases unnecessary and, as a result, some of them have been annulled. The large number of apparently active cases has led to some confusion in the use of the Code and the Boiler Code Committee has recently undertaken a thorough study of all these cases with a view to retaining only those which are considered to be active.

The result of these studies is represented in the following list of cases which are the only ones active on June 26, 1936. The present active cases include those which have been issued after that date.

The Boiler Code Committee will continue the work of making such revisions as are necessary to permit the annulment of more of these active cases in order to reduce the number to a minimum.

2	408	600	709	759	804
49	454	606	712	764	808
104	463	608	715	768	811
110	474	638	716	771	813*a*
154	505	655	719	778	817
163	515	659*b*	724	780	819
169	532	670	732	781	820
185	542	683	734	782	823
209	547	684	737	785	824
234	549	691	738	786	825
257	560	693	745	787	826
275	561	700	751	792	827
397	575	701	752	793	828
403	584	706	753	795	829
406	588	708	754	796	830

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-270. Revise to read:

P-270 The safety-valve capacity for each boiler shall be such that the safety valve or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6 per cent above THE HIGHEST PRESSURE AT WHICH ANY VALVE IS SET AND IN NO CASE TO MORE THAN 6 PER CENT ABOVE the maximum allowable working pressure.

[If the highest pressure at which any valve is set is less than the maximum allowable working pressure, the safety-valve capacity shall be such that the pressure cannot increase more than 6 per cent above this highest set pressure.]

PAR. P-271. Revise to read:

P-271 One or more safety valves on the boiler proper shall be set at or below the maximum allowable working pressure. IF ADDITIONAL VALVES ARE USED THE HIGHEST PRESSURE SETTING SHALL NOT EXCEED THE MAXIMUM ALLOWABLE WORKING PRESSURE BY MORE THAN [The remaining valves may be set within a range of] 3 per cent, [above the maximum allowable working pressure but]. The COMPLETE range of PRESSURE settings of all [of] the valves on a boiler shall not exceed 10 per cent of the highest pressure to which any valve is set.

PAR. P-272. Revise to read:

P-272 All safety valves shall be so constructed [that no shocks detrimental to the valve or to the boiler are produced and so] that THE [no] failure of any part CANNOT obstruct the free and full discharge of steam from the valve. Safety valves SHALL [may] be of the direct spring-loaded pop type, with seat [and bearing surface of the disk] inclined at any angle between 45 deg and 90 deg inclusive, to the center line of the spindle. The maximum rated capacity of a safety valve shall be determined BY ACTUAL STEAM FLOW, IN THE PRESENCE OF AUTHORIZED INSPECTORS at a pressure of 3 per cent in excess of that at which the valve is set to blow, and with a blowdown IN ACCORDANCE WITH PAR. P-281 AND CREDITED WITH 90 PER CENT OF THE FLOW DEVELOPED [of not more than 4 per cent of the set pressure, the blowdown to be in no case less than 2 lb].

Safety valves may be used which give any opening up to the full discharge capacity of the area of the opening of the inlet of the valve (See Par. P-273*c*), provided the movement of the valve is such as not to induce lifting of water in the boiler.

Dead-weight or weighted-lever safety valves shall not be used.

PAR. P-273. Revise to read:

P-273 Each safety valve [1/2 in. size and larger] shall be plainly marked by the manufacturer in such a way that the markings will not be obliterated in service. The marking may be stamped [or cast] on the casing or stamped or cast on a plate or plates securely fastened to the casing, and shall contain the following markings:

(*a*) The name or identifying trademark of the manufacturer.
(*b*) MANUFACTURER'S DESIGN OR TYPE NUMBER.
(*c*) [*b*] Size.....in. SEAT DIAMETER......IN. The pipe size of the valve inlet. [(Where the valve inlet is not threaded, the initial

diameter of the inlet shall not be less than the inside diameter of a standard pipe of the same nominal diameter as that of the valve.)]

(d) (c) Pres................lb
The steam pressure at which it is to blow.

(e) [d] B.D................lb
Blowdown. (Difference between the opening and closing pressure.)

(f) [e] Cap................lb per hr
IN ACCORDANCE WITH PARS. P-272 AND P-281 [The weight of steam discharged in pounds per hour at a pressure of 3 per cent higher than that for which the valve is set to blow,] (and with the valve adjusted for the blowdown given in the preceding item.)

(g) CAPACITY LIFT........IN.
CAPACITY LIFT—DISTANCE THE VALVE SEAT RISES UNDER THE ACTION OF THE STEAM WHEN THE VALVE IS BLOWING UNDER A PRESSURE OF 3 PER CENT ABOVE THE SET PRESSURE.

(h) A.S.M.E. SYMBOL AS SHOWN IN FIG. P-29 1/2 [Std.]

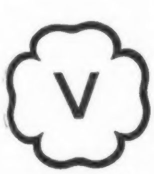


FIG. P-29 1/2

PERMISSION TO USE THE SYMBOL DESIGNATED IN THE FOREGOING PARAGRAPH WILL BE GRANTED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS TO ANY MANUFACTURER COMPLYING WITH THE PROVISIONS OF THE CODE WHO WILL AGREE UPON FORMS ISSUED BY THE SOCIETY, THAT ANY SAFETY VALVE TO WHICH THE SYMBOL IS APPLIED WILL BE CONSTRUCTED IN ACCORDANCE WITH THE CODE AND HAS THE CAPACITY STAMPED UPON THE VALVE UNDER THE STATED CONDITIONS, AND THAT HE WILL NOT MISUSE OR ALLOW OTHERS TO USE THE STAMP BY WHICH THE SYMBOL IS APPLIED.

A STEEL STAMP FOR APPLYING THE SYMBOL MAY BE PURCHASED BY SUCH MANUFACTURERS FROM THE SOCIETY.

AFTER OBTAINING THE CODE STAMP THE MANUFACTURER OF SAFETY VALVES THAT ARE TO BE STAMPED WITH THE CODE SYMBOL SHALL FIRST SUBMIT AT LEAST THREE VALVES, OF EACH OF THREE REPRESENTATIVE SIZES AND OF EACH DESIGN AND FOR THREE DIFFERENT PRESSURES, FOR TESTING AT THE PLANT OF THE MANUFACTURER OR AT A PLACE WHERE ADEQUATE EQUIPMENT IS AVAILABLE TO CONDUCT PRESSURE AND RELIEVING-CAPACITY TESTS.[2]

TESTS SHALL BE MADE TO DETERMINE THE LIFT, POPPING AND BLOWDOWN PRESSURES AND CAPACITY FOR AT LEAST THREE POINTS IN THE EXPECTED RANGE OF PRESSURES AND CAPACITIES FOR WHICH THE VALVE IS TO BE USED IN ORDER TO ESTABLISH THE PERFORMANCE FOR EACH SIZE AND DESIGN.

THE TESTS SHALL BE MADE WITH STEAM AND IN A MANNER CLOSELY APPROXIMATING ACTUAL OPERATING CONDITIONS ON STEAM BOILERS, THE RELIEVING CAPACITY SHALL BE MEASURED BY CONDENSING THE STEAM OR WITH A CALIBRATED STEAM FLOW METER.

[2] Facilities available at the present time may impose limitations on the testing of some valves at high pressures and of large capacity.

THESE TESTS SHALL BE CONDUCTED IN THE PRESENCE OF, AND CERTIFIED BY, A STATE INSPECTOR, A MUNICIPAL INSPECTOR OR AN INSPECTOR REGULARLY EMPLOYED BY AN INSURANCE COMPANY AUTHORIZED TO INSURE BOILERS AGAINST EXPLOSION IN THE STATES AND MUNICIPALITIES THAT HAVE ADOPTED THIS CODE.

A DATA SHEET FOR EACH SAFETY VALVE TESTED SHALL BE FILLED OUT AND SIGNED BY THE MANUFACTURER AND THE INSPECTOR WITNESSING THE TEST. SUCH DATA SHEET WILL BE THE MANUFACTURER'S AUTHORITY TO BUILD AND STAMP VALVES OF CORRESPONDING DESIGN AND CONSTRUCTION. WHEN CHANGES ARE MADE IN THE DESIGN, SIMILAR TESTS MUST BE REPEATED.

THE RELIEVING CAPACITY THAT MAY BE STAMPED ON THE SAFETY VALVES SHALL NOT EXCEED 90 PER CENT OF THE VALUE DETERMINED BY THE WITNESSED TESTS.

PAR. P-276. Revise to read:

P-276 When two or more safety valves are used on a boiler, they may be mounted either separately or as twin valves made by placing individual valves on Y bases, or duplex [triplex or multiplex] valves having two [or more] valves in the same body casing. TWIN [the] valves MADE BY PLACING INDIVIDUAL VALVES ON Y BASES OR DUPLEX VALVES HAVING TWO VALVES IN THE SAME BODY shall be [made] of equal sizes [if possible, and in any event if not of the same size].

WHEN NOT MORE THAN TWO VALVES OF DIFFERENT SIZES ARE MOUNTED SINGLY, THE RELIEVING CAPACITY OF the smaller [of the two] valve shall NOT BE LESS THAN [have a relieving capacity of at least] 50 per cent of that of the larger valve.

PAR. P-277. Omit the words "when possible" at the end of this paragraph.

PAR. P-278 Revise last sentence of second section to read:

For iron- and steelbodied valves exceeding 2 in. size, the drain hole shall be tapped NOT LESS THAN 3/8 IN. PIPE SIZE.

PAR. P-281. Revise to read:

P-281 *a* Safety valves shall operate without chattering and shall be set and adjusted as follows: To close after blowing down not more than 4 per cent of the set pressure but not less than 2 lb in any case. For spring-loaded pop safety valves [operating on] FOR pressures [up to and including] BETWEEN 100 AND 300 lb per sq in., BOTH INCLUSIVE, the blowdown shall not be less than 2 per cent of the set pressure. To insure the guaranteed capacity and satisfactory operation, the blowdown as marked upon the valve (Par. P-273*e*) shall not be reduced.

(*b*) THE BLOWDOWN ADJUSTMENT SHALL BE MADE AND SEALED BY THE MANUFACTURER.

(*c*) THE POPPING POINT TOLERANCE PLUS OR MINUS SHALL NOT EXCEED THE FOLLOWING: 2 LB FOR PRESSURES UP TO AND INCLUDING 70 LB, 3 PER CENT FOR PRESSURES FROM 71 TO 300 LB, AND 10 LB FOR PRESSURES OVER 300 LB.

PAR. P-282. Revise to read:

P-282 To insure the valve being free, each safety valve [on boilers with maximum allowable working pressures up to and including 200 lb per sq in.] shall have a substantial lifting device by which the valve disk may be positively lifted from its seat [at least 1/16 in.] when there is AT LEAST 75 PER CENT OF FULL WORKING [no] pressure on the boiler. THE LIFTING DEVICE SHALL BE SUCH THAT IT CANNOT LOCK OR HOLD THE VALVE DISK IN LIFTED POSITION WHEN THE EXTERIOR LIFTING FORCE IS RELEASED. [For boilers with working pressures above 200 lb per sq in., the safety-valve lifting device need not provide for lifting the valve disk 1/16 in. except at such times as there is at least 75 per cent of the full working pressure upon the boiler. Except at times of general inspection, the valve should not be lifted, unless there is sufficient steam pressure on the boiler to blow the dirt and scale clean from the seat.]

PAR. P-284. Revise the first sentence to read:

P-284 Springs used in safety valves shall not show a permanent set exceeding 1 PER CENT OF THEIR FREE LENGTH [1/16 in.] ten minutes after being released from a cold compression test closing the spring solid.

PAR. P-285. Revise to read:

P-285 *a* The spring in a safety valve IN SERVICE, FOR PRESSURES UP TO AND INCLUDING 250 LB shall not be used for any pressure more than 10 per cent above or 10 per cent below that for which it was designed. FOR HIGHER PRESSURES THE SPRING SHALL NOT BE USED FOR ANY PRESSURE MORE THAN 5 PER CENT ABOVE OR 5 PER CENT BELOW THAT FOR WHICH IT WAS DESIGNED.

b IF THE OPERATING CONDITIONS OF A VALVE ARE CHANGED SO AS TO REQUIRE A NEW SPRING UNDER (*a*) FOR A DIFFERENT PRESSURE, THE VALVE SHALL BE ADJUSTED BY THE MANUFACTURER OR HIS AUTHORIZED REPRESENTATIVE WHO SHALL FURNISH AND INSTALL A NEW NAME PLATE AS REQUIRED UNDER PAR. P-273.

PAR. P-286. Revise the second sentence of this paragraph to read as follows:

The dimensions of flanges subjected to boiler pressure shall conform to the American Standards as given in Tables A-5 to A-8 in the Appendix, subject to the restrictions of Par. P-12*b*. [except that the face of a safety valve flange and the face of a nozzle or fitting to which it is attached may be flat without the raised face for pressures not exceeding 250 lb per sq in. but for higher pressures shall] THE [have] facings SHALL BE similar to those shown in Fig. A-9 [and of dimensions given in Table A-5 in the Appendix].

PAR. P-287. Revise to read:

P-287 When the valve casing is marked as required by Par. P-273, it shall be the guarantee by the manufacturer that the valve ALSO conforms to the details of construction herein specified.

PAR. P-289. Revise the second sentence of this paragraph to read as follows:

The valve shall have a flanged inlet connection, and shall have the seat and disk of SUITABLE HEAT EROSIVE- AND CORROSIVE-RESISTING [nickel composition or equivalent] material, and the spring fully exposed outside of the valve casing so that it shall be protected from contact with the escaping steam.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Story of Bridges

THE STORY OF BRIDGES. By Archibald Black. Whittlesey House, McGraw-Hill Book Company, Inc., New York, N. Y. Buckram, 6 × 9 in., 226 pp., $2.50.

REVIEWED BY OTIS E. HOVEY[1]

TWENTY-NINE hundred years ago the preacher commented "of making many books there is no end, and much study is a weariness of the flesh."

Here is a book the study of which is not a weariness of the flesh, but a recreation; not that it is trivial, but because the author has transformed the history of the evolution of bridges and bridge building into a fascinating story well told. The story is not arranged in strictly chronological order, for it begins with an account of the building of two of the most recent and modern of bridges, including comments on some of the unusual and difficult problems encountered in their construction.

Succeeding chapters trace the evolution of bridges, beginning with the earliest and crudest, proceeding from one type to another, and working up to the most economical, practicable, and recent designs that have been found best adapted to definite situations and local conditions. Logs to masonry arches, wooden trusses to those of iron and then steel, cantilever and suspension bridges, reinforced-concrete types, and movable spans are discussed in turn. Several chapters treat of unusual designs, of foundation and foundation problems, and of the difficult erection problems encountered in the construction of some types of bridges.

The "Story of Bridges" might be termed the romance of bridges, but the romance is based upon verified historical data. There are interesting anecdotes, many of which may not be widely known, and their inclusion increases the pleasure of the reader.

The book contains no theory—one cannot read about how to design a bridge—but much has been included that indicates why one or another type of design was chosen to meet definite conditions at the site of a bridge.

[1] Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

Many excellent and carefully selected photographs illustrate the text.

This book is so different from any that has previously been written on the subject that all bridge engineers, bridge builders, and interested laymen should read it, and they will be well repaid for their time and attention.

Diesel Fuel Testing

THE DEVELOPMENT OF DIESEL FUEL TESTING. By T. B. Hetzel. The Pennsylvania State College Bulletin, No. 45, 1936. Paper, 6 × 9 in., 59 pp., 29 figs., 9 tables, $0.50.

REVIEWED BY H. SCHRECK[2]

THIS work serves two purposes, both in an excellent manner. In the first place, it gives a complete review of what has been done by various authorities in the way of assessing the ignition quality of Diesel fuels on the basis of the cetane number, Diesel index, etc. In the second place, the author presents an improved method developed by Prof. P. H. Schweitzer at the Pennsylvania State College.

[2] Assistant Chief Engineer, Fairbanks, Morse & Co., Beloit, Wis. Mem. A.S.M.E.

It is a modification of and improvement on the C.F.R. (Cooperative Fuel Research) engine now being used as standard procedure for the determination of knock ratings. The modification is twofold. The modified C.F.R. engine is adjusted for fixed ignition lag, the injection is set for 20 deg before dead center, and compression is varied for ignition to take place at dead center. The C.F.R. engine is adjusted for injection at approximately 11 deg before dead center and for ignition 1 deg after dead center. By this modified method about eight samples can be tested in an hour as against one sample per hour with the C.F.R. engine.

The second important improvement in the modified engine is the elimination of the bouncing pin which introduces inaccuracies and trouble due to sparking when breaking the electrical contact.

This work should lead Diesel engineers to accept this modified method and, most of all, encourage the A.S.T.M. to accept it as standard.

Books Received in Library

DIE KNICKFESTIGKEIT VON STÄBEN UND STABWERKEN. By J. Ratzersdorfer. Julius Springer, Vienna, 1936. Cloth and paper, 6 × 9 in., 321 pp., diagrams, charts, tables; cloth, 28.80 rm.; paper, 27 rm. An investigation of a number of important problems of elastic stability. Some twenty-nine cases of bars and frameworks are considered and their resistance to buckling under various conditions is studied and detailed solutions provided. The problems are important ones in the statics of structures, and the methods can be easily applied to other cases.

KORROSION V. Bericht über die Korrosionstagung 1935 am 18 und 19. November, 1935, in Berlin. V.D.I. Verlag, 1936. Paper, 6 × 8 in., 120 pp., illus., diagrams, charts, tables, 7.50 rm. The volume contains the papers presented at a symposium on corrosion, at Berlin in November, 1935, in which five of the principal engineering and chemical societies of Germany took part. Special attention was directed to the chemical side of corrosion. General questions of corrosion, corrosion by cold water, and methods of prevention were discussed.

HOW TO FIND METALLURGICAL INFORMATION. By R. Rimbach. 1117 Wolfendale St., Pittsburgh, Pa., 1936. Paper, 9 × 12 in., 32 pp., $1. This pamphlet provides sound practical advice to the searcher for metallurgical information, by calling attention to the available indexes, abstracting services, and general reference books, and indicating how the best use can be made of libraries. A long list of metallurgical books now in print is included.

METALS HANDBOOK, 1936 edition. Published by American Society for Metals, Cleveland, Ohio. Leather, 6 × 9 in., 1392 pp., illus., diagrams, charts, tables, $10, to members, $5. The 1936 edition of this valuable work shows much improvement. Many new topics have been introduced and the different sections have been carefully revised. A larger format and better paper make the work more convenient to use. Useful, up-to-date bibliographies accompany the various sections. Both ferrous and nonferrous metallurgists and users of metals will find the volume indispensable as an authoritative reference book.

MITTEILUNGEN DES HYDRAULISCHEN INSTITUTS DER TECHNISCHEN HOCHSCHULE, MÜNCHEN, Heft 8. Edited by D. Thoma. R. Oldenbourg, Munich and Berlin, 1936. Paper, 8 × 11 in., 98 pp., illus., diagrams, charts, tables, 7.50 rm. This publication contains four communications from the Institute. The first, "Experiments with the Hydraulic Back-Flow Throttle," describes work with a

throttling device for pipe lines which has no moving parts and provides much greater opposition to counterflow than the normal flow. The second paper, "Investigations of the Behavior of a Centrifugal Pump Operating in the Cavitation Range," describes tests throughout the entire range to complete cavitation. Paper three, "Investigations of Complete and Partial Overflows," describes tests upon various types of weirs, especially under conditions of high tail-water level. The final report, "The Generation of Power by Fluttering," discusses the vibration of bodies in fluids, such as those of electric lines in the wind.

NATURE OF PHYSICAL THEORY. By P. W. Bridgman. University Press, Princeton, N. J. Cloth, 6 × 9 in., 138 pp., $2. This interesting, thought-provoking little book contains in expanded form the three Vanuxem lectures delivered at Princeton University in December, 1935. It is primarily concerned "with a critical analysis of the points of view and methods which we adopt in trying to understand the simpler aspects, taken to be within the domain of physics, of the ever-changing spectacle about us." The volume represents, says Dr. Bridgman, his "personal attempt as an experimental physicist to appreciate more clearly what are the possibilities open to us in our endeavor to reduce the material of experimental physics to order and understandability."

ORGANIZATION AND MANAGEMENT IN INDUSTRY AND BUSINESS. By W. B. Cornell. Ronald Press Co., New York, 1936. Cloth, 5 × 8 in., 802 pp., illus., diagrams, charts, tables, $4.50. This is a revised edition of "Industrial organization and management," modified by giving a broader, more general treatment to the subjects discussed and by adding some things which affect business but are outside the control of management. The book aims to provide a comprehensive course of training in the organization, management, and operation of every department of a business concern, including both commercial and industrial activities.

OUTLINE OF METALLURGICAL PRACTICE. By C. R. Hayward. D. Van Nostrand Co., New York, 1929. Cloth, 6 × 9 in., 612 pp., illus., diagrams, charts, tables, $7.50. This volume covers in outline and in a rather elementary manner, modern practice in extracting and refining most of the metals, accompanied by general information regarding their sources, uses, important alloys, and principal literature. As a ready reference book for the engineer, the work should prove very useful. Beginning students will also find it a valuable guide for their thinking and reading.

PHYSICAL CONSTANTS OF PURE METALS. Edited by National Physical Laboratory. His Majesty's Stationery Office, London, 1936. Paper, 6 × 10 in., 27 pp., tables, 6d. (Obtainable from British Library of Information, New York, $0.20.) This pamphlet presents the results of determinations carried out during the past fifteen years, partly upon specially pure metals prepared by the National Physical Laboratory and partly upon metals of high commercial purity. The results of determinations by other institutions are also given.

PHYSICS OF SOLIDS AND FLUIDS with Recent Developments. Part 2. By L. Prandtl, authorized translation by W. M. Deans. Second edition. Blackie & Son, London and Glasgow, 1936. Cloth, 6 × 9 in., 392 pp., illus., diagrams, charts, tables, 12s 6d. This volume contains a translation of the articles on the equilibrium and the flow of liquids and gases which Professor Prandtl contributed to the eleventh edition of Mueller-Pouillet's "Lehrbuch der Physik." The present edition has been revised, considerable additions discussing recent work have been made, and a new chapter on the dynamics of gases has been included. There is a bibliography. The engineer will find much of value on the practical applications of hydrodynamics in the book.

TOOLMAKING. International Textbook Co., Scranton, Pa., 1935. Leather, 5 × 6 in., illus., diagrams, charts, tables, $1.80. A manual of practical advice on toolshop equipment and toolmakers' methods.

THIS MONTH'S AUTHORS

A. G. CHRISTIE, professor of mechanical engineering, the Johns Hopkins University, member A.S.M.E., is well known to readers of MECHANICAL ENGINEERING for his many papers on steam power plants and steam turbines. As a young man he resigned an instructorship in Cornell University to take charge of the erection and operation of the first steam turbine built by Allis-Chalmers. It was this experience, combined with his later work in steam turbines, some of which is alluded to in his paper, that led him to prepare this present historical summary of contributions to the steam-turbine art by the Allis-Chalmers Company.

LEE SCHNEITTER, member A.S.M.E. and author of the paper on "Diesel-Engine-Maintenance, Operating, and Outage Data," is Diesel plant betterment engineer with Ebasco Services Inc., a subsidiary of the Electric Bond & Share Co., New York, N. Y. Mr. Schneitter received the degrees of A.B. and M.E. in 1919 and 1920 from the University of Missouri. He was connected with the Kansas City Power & Light Co. for a year as appraisal engineer and then became Diesel engineer with the Texas Power & Light Co., at Dallas, Tex. From 1923 to 1925 he served as Diesel engineer in plant-betterment work for the Cia Cubana de Electricidad at Havana, Cuba, afterward becoming associated with the Electric Bond & Share Co.

R. BAUDRY and L. M. TICHVINSKY are coauthors of the paper in this issue on "Performance of Oil Rings." Mr. Baudry, member A.S.M.E., was graduated from l'École National D'Arts et Metiers in 1919 with the degree of M.E., then serving for four years in the technical service of the French aeronautical department, Paris, as machine designer. After a year with the French "Comité des Forges" in the inspection of coal mines and the study of coke ovens, he came to the United States and entered the employ of Sargent & Lundy, Inc., Chicago, as draftsman. In 1925 he became associated with the Westinghouse Electric & Manufacturing Co., as machine designer, later becoming development engineer, responsible for the mechanical design of large a-c generators, including the study and development of new rotor designs, the application of electric welding, and the design of large journal and thrust bearings.

Mr. Tichvinsky studied for six years at the Prague Polytechnic Institute in Czechoslovakia. In 1928 he received his degree in mechanical engineering. Since 1929 he has been associated with the Westinghouse Electric & Manufacturing Co., where he is in the research laboratories in charge of work on lubrication, friction, and wear of metals.

E. L. MCDONALD, member A.S.M.E., and RAY WINTERS, coauthors of "Heat Balance Versus Weighed Boiler Tests," are both connected with the Kansas City Power & Light Co. Mr. McDonald who received his technical education at Armour Institute of Technology, was associated with the Commonwealth Edison Company in Chicago from 1904 to 1919 in plant operation and betterment work. He has been with his present concern since 1919.

Mr. Winters holds the position of testing engineer with the company. He received the degree of B.S. in mining engineering in 1920. After a year in the testing and research department of the Anaconda Copper Co., he joined the efficiency department of the Kansas City Power & Light Co.

R. C. H. HECK, research professor of mechanical engineering at Rutgers University, in his article on "The Keenan and Keyes Steam Tables" reviews the book on Thermodynamic Properties of Steam. Professor Heck has been a student of this subject for many years. In 1920 he contributed an extensive paper "Steam Formulas" to the A.S.M.E. in which he reviewed proposed equations of state for steam and presented certain equations of his own which he compares, in the present review, with the new tables and formulation by Keenan and Keyes. He has been a member of the A.S.M.E. special research committee on the Thermal Properties of Steam since its organization in 1921. It was this committee under whose guidance fundamental researches in this subject were made at Harvard, under Harvey N. Davis, at M.I.T. under Dr. F. G. Keyes, and at the Bureau of Standards under Dr. N. S. Osborne, out of which the Keenan tables, published by the A.S.M.E. in 1930, were developed.

RUSSELL NIXON, author of the review on "Ebb and Flow in American Unionism" is an assistant in the department of economics and social science, Massachusetts Institute of Technology. He received the degree of A.B. *magna cum laude*, at the University of Southern California in 1934, and is now working toward his Ph.D. in the graduate school of economics, Harvard University.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Engineers Attend A.E.C. Assembly Meeting at Washington

Admiral Cone Made A.S.M.E. Honorary Member

THE Mayflower Hotel, Washington, D. C., was the scene, January 14 to 16, of the Seventeenth Annual Assembly of the American Engineering Council and the Seventh Conference of Engineering Society Secretaries. Representatives of the 48 national, state, and local societies which comprise the Council were present. The American Society of Mechanical engineers was represented by its A.E.C. Delegation, consisting of James H. Herron, Ralph E. Flanders, Paul Doty, W. L. Batt, and Eugene W. O'Brien (who served as alternate to L. P. Alford). Attending the assembly and a concurrent meeting of the Executive Committee of the A.S.M.E. were also W. A. Shoudy, H. R. Westcott, J. W. Parker, and Kenneth H. Condit, with K. M. Irwin and J. N. Landis representing the A.S.M.E. Finance and Local Sections committees. The Society was also represented at the Secretaries' Conference by C. E. Davies, secretary, and Ernest Hartford, assistant secretary, A.S.M.E. Many other members of the Society were in attendance as representatives of other societies and engineers' clubs.

ADMIRAL HAROLD J. BOWEN

ADMIRAL HUTCHINSON I. CONE, RETIRED

Because the meeting of the A.E.C. Assembly and the A.S.M.E. Executive Committee attracted so many A.S.M.E. officers, Council members, and delegates, the A.S.M.E. Washington Section, M. X. Wilberding, chairman, held a dinner in honor of the visitors on Thursday night at the Hay-Adams House. To an audience of approximately 40, including several student members, President Herron, R. L. Sackett, senior Councilor of Group III, and Admiral H. I. Cone spoke informally. Capt. Duncan, of the United States Navy, was a guest at the dinner.

A session on programs of united action for member societies opened the Conference of Secretaries of Engineering Societies on Thursday morning, O. L. Angevine, secretary of the Rochester Engineers Club, presiding as chairman of the conference. Among the many discussions were those by A. A. Potter, president, A.E.C., who spoke on intersociety cooperation, Watson Davis, of Science Service, whose subject was publicity, and F. J. Chesterman, who talked about public affairs. The conference continued throughout the afternoon with discussions on the coordination of programs and meeting dates, the Third World Power Conference, and various programs local societies had found to be successful.

Thursday afternoon was also the occasion for meeting in informal round-table discussion of the A.E.C. divisional committees. With F. M. Feiker, executive secretary, A.E.C., presiding, A. A. Potter, president, A.E.C., opened the discussion on operating committees. The session was devoted to a preliminary discussion of reports of A.E.C. committees that were presented on Friday. Secretary and Mrs. Feiker entertained the delegates at a reception and tea at their home at the close of the session.

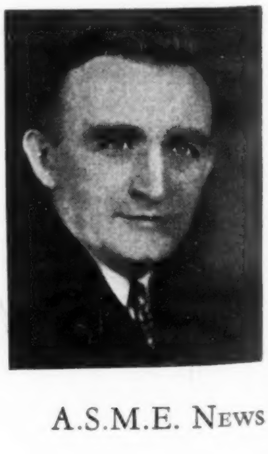
At a symposium on public affairs held on Thursday evening, F. J. Chesterman, chairman, several important questions engaging the attention of the Administration and the Nation were discussed, such as social security, old age, and unemployment compensation, industrial cooperation with and without government supervision, conservation of natural resources, national, state, and local public works activities, and rural electrification. The speaker on social security was Arthur J. Altmeyer, of the Social Security Board. Col. E. W. Clark, executive assistant, Public Works Administration, in his address, made a plea for greater social-mindedness in engineers. In his discussion of natural resources, Thomas R. Tate, chief, Power Resources Division, Federal Power Commission, displayed numerous large-scale maps of power systems in the United States, including one showing the geographical regions into which it is proposed to divide the nation for purposes of power production and distribution.

At the business session on Friday morning, A. A. Potter presiding, a roll call of representatives was followed by the president's address, and reports of the executive secretary, treasurer, and numerous operating committees.

President Potter spoke briefly on the efforts Council had made during the year to encourage the activities of the committees and to coordinate the work of engineering societies. He spoke of the need for more factual data on the impart of technology on social security and urged the active support of the Council in efforts to assist in their determination and dissemination, in the hope that the public more generally may come to regard engineering and the engineer in their true economic and social significance.

Mr. Feiker read a report which covered the varied and important work of the Council and its numerous committees. Unfortunately, limitations of space forbid even a summary of Mr. Feiker's report, but plans are under consideration to bring the Councils' activities before the readers of MECHANICAL ENGINEERING in later issues.

The report of the treasurer showed successful operation of the Councils' financial affairs within the income received and a balance of approximately $2000 to carry over into 1937. A budget of estimated expenditures for 1937 amounting to $39,431 was adopted. Reports were presented on publicity, membership and representation, regional activities, finance, constitution and by-laws, and nominations.



SENATOR JOSEPH C. O'MAHONEY

Abel Wolman, chairman, Water Resources Committee, addressed the Assembly luncheon on the engineer's opportunities and responsibilities in the conservation of natural resources.

Mr. Wolman's excellently delivered address reviewed the steps by which, from the pressure of PWA activities, and the work of the Mississippi Valley Committe, and the Water Planning Board, the Water Resources Committee was evolved. He described briefly some of the more important principles of action of the Water Resources Committee. One was the development of coordinated national water plans. Another that national water development concerned people primarily, rather than merely water. It was essential, he said to effect a centralization of points of view on a river basin as a whole in order to obtain a necessary perspective. He then described briefly some specific undertakings of the committee and the work of several subcommittees that experience had shown that it was necessary to organize.

Following the luncheon reports of numerous public-affairs committees of the A.E.C. were presented. F. J. Chesterman presided.

Although it is impossible to summarize the numerous reports presented, it may be stated that extensive discussions followed the presentation of the reports on patents, R. S. McBride, chairman; public works, Alonzo J Hammond, chairman; rural electrification, L. F. Livingston, chairman; conservation and utilization, Leonard J. Fletcher, chairman, and surveys and maps, John S. Dodds, chairman. These reports were accepted and referred to the executive committee for action.

Morris L. Cooke, administrator, Rural Electrification Administration, spoke on the achievements of the R.E.A. which he characterized as "rural electrification in spite of the experts." His three levels of interest in the work, were, he said, (1) that of "gadgets," the electrical devices themselves, (2) that of the "cultural renaissance for agriculture," and (3) national survival as threatened by unwise use of soil and water.

As usual, the high point of the A.E.C. annual assembly was the "All Engineers' Dinner," held on Friday night with about 400 in attendance and President A. A. Potter presiding. A reception preceded the dinner.

This year the dinner was of more than usual interest to members of The American Society of Mechanical Engineers because it was the occasion of the presentation of honorary membership to Admiral Hutchinson I. Cone.

DR. C. F. HIRSHFIELD

Acting as toastmaster was Col. D. H Sawyer, director, Federal Employment Stabilization Board, who introduced Messrs. Angevine, Bickelhaupt, McCutcheon, Mead, Coleman, Feiker, and Blasingame, and spoke on the construction during the depression.

Admiral Cone was presented by M. X. Wilberding, chairman of the A.S.M.E. Washington Section. In introducing Admiral Cone, Mr. Wilberding spoke briefly of his career.

Admiral Cone has been a member of The American Society of Mechanical Engineers since 1910. He first attracted general notice as fleet engineer when the whole Navy went around the world in 1908–1909, during Theodore Roosevelt's administration. This bold venture was a success because Cone had so organized the continuous inspection and maintenance of machinery and power plants afloat

COL. D. H. SAWYER

FREDERICK M. FEIKER

that the fleet functioned perfectly at great distances from navy yards and repair bases. He was given full credit for this engineering feat that made the modern steam Navy "as seagoing as the old sailing frigates."

His achievement led on May 2, 1909, to his appointment by the President as engineer-in-chief and chief of the Bureau of Steam Engineering with the rank of rear-admiral although only a lieutenant-commander. At the age of 38 he was the youngest man ever to be selected for this highly important task or responsibility as head of any naval bureau. As engineer-in-chief, he consolidated the scheme of fleet maintenance, influenced design and construction of machinery to support it, and established a fixed engineering policy which is followed today. During his period of service two outstanding developments began, namely, the change from the coal burning to oil burning in Navel vessels and investigations which led to adoption of electric drive for Naval vessels. The Bureau of Steam Engineering under his guidance kept to the forefront in engineering progress, particularly along electrical lines and the development of efficient propellers.

During the War Cone was called by Admiral Sims to take command of all U. S. Naval Aviation Forces in Europe. By sound engineering planning and administration Cone brought these forces to an excellent standard of equipment and training for the performance of extremely useful service.

Cone retired from the Navy in 1922 with the rank of rear-admiral and after a short period with the Panama Railroad Steamship Line in 1924 and 1925 served as vice-president and general manager of the U. S. Shipping Board Emergency Fleet Corporation.

In 1926 and 1927, Admiral Cone served as vice-president and treasurer of the Daniel Guggenheim Fund for Promotion of Aeronautics. In this capacity, he directed the disbursement of $5,000,000 with excellent results in the advancement of aeronautic science and in improved public understanding of the possibilities of aviation in commercial transport.

In 1928, he returned to the Shipping Board as commissioner, resigning in March, 1935. He proposed a program of engineering development and secured appropriations therefor from Congress. This led to a series of investigations of new and improved methods of shipbuilding and propulsion. Model-basin experiments included propeller research and studies of hull forms. Tests of ships for comparison with model performance were made. Experiments into the possibilities of increasing speed and efficiency of existing ships were conducted. The data secured in these tests were made available so that Admiral Taylor's "Speed and Power of Ships" could be brought up to date and published.

In responding to the speech of presentation by President Herron, Admiral Cone expressed his appreciation of the honor done him and said that he would maintain the high standards set by those distinguished engineers who had previously been elected to honorary membership.

The principal addresses at the dinner were by Rear-Admiral Harold J. Bowen, engineer-in-chief of the United States Navy, who spoke on national defense, by Hon. J. C. O'Mahoney, senator from the State of Wyoming, on the interstate regulation of business by federal license, and by C. F. Hirshfeld, member A.S.M.E., whose subject was the engineer's responsibilities in social and economic questions. Because of Mr. Hirshfeld's illness his address was read by R. L. Sackett.

Admiral Bowen said that a modern navy is highly mechanized and depends on the engineer for maintenance, and called attention to the diversity and extent of the vessels, aircraft, shore establishments, and communication systems of which it is comprized. He gave many examples of the stimulation to naval engineering coming from industry, as well as that received by industry from the Navy. In closing he asserted that naval defense is a struggle between applied science as utilized by the combatants and that a navy cannot rise above the

level of the engineering development of the nation to which it belongs.

In his penetrating and carefully reasoned address Mr. Hirshfeld urged the engineer to enlarge the sphere of his influence by accepting a larger measure of responsibility in solving social and economic problems resulting from the impacts of applied science. He made a plea for a factual study of such grave questions as technological unemployment, relative returns to capital and labor of the fruits of industry, and competition. As examples of public questions in which engineers might interest themselves in their own communities as a public service he mentioned traffic regulation, air pollution, noise abatement, and public transportation. He closed by asking whether or not the engineer would have the fortitude to serve humanity in the future in the same grand manner in which he had served it on technological matters in the past.

Senator O'Mahoney gave numerous examples of corporation created under the laws of a single state which do business in several or all states and in world trade, and argued that there exists a need for the regulation of interstate business by means of federal licenses. He explained some of the principle features of a bill before the Congress introduced by him as a device for the regulation be proposed.

Continuing its meeting on Saturday morning with a session on engineering economics, the assembly listened to further reports. Mr. Chesterman made a plea for engineers to take a broader view of their profession in line with the thoughts expressed in Mr. Hirshfeld's address at the dinner, and had a discussion on effective publicity on engineers and their work.

C. E. Stephens reported for several of the united action committees, and a resolution was passed in favor of an extension of the merit system.

In presenting a report of the engineering economics committees Ralph E. Flanders reviewed the status of the third progress report of the committee on consumption, economics, and distribution. For the committee on special surveys and studies he made the proposal, referred to the executive committee by vote of the Assembly, that the Council bring about cooperation between its engineering economics committees and social-science groups.

J. Frederic Dewhurst, of the Committee on Social Security of the Social Science Research Council, spoke briefly on social science and engineering. The engineering profession, he said, was in a position to make a contribution to the preventive side of social security.

Officers elected at the Assembly meeting were, for vice-presidents C. O. Bickelhaupt, A.I.E.E., and John S. Dodds, representing the state and local member organizations. C. E. Stephens was elected treasurer. In all cases these were reelections. The term of president is for two years, and as Dean Potter has served but one, he will continue in that office for 1937. Representatives and alternates to the Assembly were also elected. F. M. Feiker was reelected executive secretary. Chairman of committees selected were William McClellan, finance committee; C. O. Bickelhaupt membership and representation; and F. J. Chesterman, public affairs.

The Members' Page

A Forum for Frank Discussion of A.S.M.E. Affairs

Boost The Speakers' Forum

The Members' Page:

I enthusiastically endorse the gift of a "Members' Page" by Past-President Batt and all eligible should use it in the ways proposed.

One actively continuing but modest branch of the Society should be encouraged into broader activities. With a little boosting of the work of the Speakers' Forum, more members would easily learn how to address gatherings, large or small.

During winter months, regular postal notice might be sent to members and their friends within a radius of 50 miles. Any person presenting one of the postal notices should be eligible to attend meetings of the Forum. Public meetings devoted to the discussion of current subjects could be arranged to be held in the Auditorium for which the list of speakers should be selected from the personnel of the Speakers' Forum by a Committee of the Forum.

Such interest would be aroused that the Forum would enlist large new membership and develop a healthy competition for speaking assignments at the public meetings. It would also provide an inducement for members to join the Society.

Joseph C. Bonner.[1]

[The Speakers' Forum of the Metropolitan Section of the A.S.M.E. was organized about five years ago by a group of fellow engineers, who, realizing the great value of effective speaking, had previously attended courses as sponsored by the Section.

It affords an opportunity to engineers to get further practice in the art of speaking and presentation of addresses and to acquire experience and confidence in themselves to express their views in the most effective manner.

Meetings are held every Thursday and the present active enrollment is about 50 to 60 members.

This activity, according to the chairman of the Forum, Adolf Ehbrecht, is proving of great benefit not only to the members individually but to the Society as well.]

[1] Bonner Railwagon System, Inc., New York, N. Y. Mem. A.S.M.E.

Engineering Opinion on Local Projects

The Members' Page:

Accepting the opportunity offered by Past-President Batt in the new "Members' Page," may I raise the question of methods of getting engineering opinion before local boards of public officers? The need for unbiased engineering reports on many public questions is obvious. There should never be political argument over statements of fact.

A vivid example is the long-drawn-out discussion of subway plans before the San Francisco Board of Supervisors. Competent engineering studies had been made and were forcefully presented in favor of one system. However, other plans were brought before the Board of Supervisors and much useless argument followed.

I should like to suggest that the critical engineering analysis of such extra plans can well be made a proper function of the junior members of the local engineering societies interested. Their joint report can be made public without endangering the jobs of the members (often impossible for senior members because of political connections), and the supervisors need not pay official attention to it, because it is not a formal recommendation of the engineering societies.

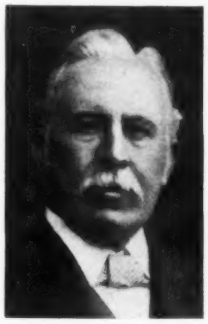
In the public mind it would accomplish two results: (1) A segregation of factual questions from those of policy proper; and (2) some extra confidence for the plan that had best withstood the sharp criticisms expected from young men. As an effective activity for junior members it should rank high.

There is need for extensive legislative discussions of questions of public policy but these policy questions are already so serious that some persons despair of our keeping a democratic system of government in operation. Hence, the greatest public contribution by engineers is to simplify political arguments by segregating the demonstrable facts so that the public discussions can be properly confined to questions of policy.

F. A. Brooks.[2]

[2] Division of Agricultural Engineers, College of Agriculture, Davis, Calif., Mem. A.S.M.E.

Sir John Aspinall First to Receive Watt Medal



SIR JOHN ASPINALL

THE first award of the James Watt International Medal was made to Sir John A. F. Aspinall, honorary member A.S.M.E., by the Institution of Mechanical Engineers (Great Britain).

The Medal was established by the Council of the Institution at the time of the celebration in 1936 of the Bicentenary of the birth of James Watt. It is to be awarded biennially with the cooperation of mechanical engineering societies in leading industrial countries throughout the world for outstanding achievements in mechanical engineering.

Sir John Aspinall is well known as a railway engineer and administrator. He was born in Liverpool and studied at Beaumont College and the University of Liverpool. When he, as chief engineer of the Lancashire and Yorkshire Railway, was appointed its general manager, it was the first time an engineer had ever been put on the traffic side of a railway in England. His success dispelled forever the legend that an engineer was too technical to take charge of a vast business. His part in transporting the army to the coast in 1914, with its field equipment, was one of the most remarkable features of England's early war efforts.

A.S.M.E. Calendar
of Coming Meetings

February 26, 1937
Process Industries Meeting
Rutgers University

May 14–15, 1937
National Rayon Textile
Conference, Washington, D. C.

May 17–21, 1937
Semi-Annual Meeting
Detroit, Mich.

May, 1937
Graphic Arts Meeting,
New York, N. Y.

June 24–25, 1937
Applied Mechanics Meeting
Cornell University

August, 1937
Oil and Gas Meeting
Pennsylvania State College

October, 1937
Wood Industries Meeting
Louisville, Ky.

Local Sections Meetings
See page 140

Agricultural Processing Meeting

To Be Held at Rutgers University, February, 26

UNDER the joint auspices of the Process Division of the A.S.M.E., the American Society of Agricultural Engineers, and the Farm Chemurgic Council, an agricultural processing meeting will be held on February 26, 1937, at Rutgers University in New Brunswick, N. J.

The detailed program for this meeting follows:

9:30 a.m.

Registration in Chemistry Lecture Room or Physics Laboratory, $1, including luncheon

10:00 a.m. Morning Session

Chairman: L. F. Livingston

Processing Research in Agriculture, by John F. Ferris, acting director, Agricultural Industrial Division, TVA

Processing Flax and Hemp, by George A. Lowry, Lowry & Grant, New York, N. Y.

1:00 p.m.

Luncheon at University cafeteria with speakers who will give accounts of various agricultural researches.

2:30 p.m. Afternoon Session

Chairman: Victor Wichum, Chairman A.S.M.E. Process Industries Division

Processing Engineering in Agriculture, by L. F. Livingston, President, American Society of Agricultural Engineers

Drying of Agricultural Products—Technical and Economic Aspects, by C. W. Thomas and A. Weisselberg, members of the Drying Committee of the A.S.M.E. Process Industries Division.

Members of the Society and their friends who plan to attend this meeting are requested to send their names as an advance registration to Prof. R. C. H. Heck, Agricultural Processing Meeting, Rutgers University, New Brunswick, N. J.

New Edition of Who's Who in Engineering Now in Preparation

THE fourth edition of "Who's Who in Engineering" is now in the course of preparation and data blanks have been sent to every engineer for whom a permanent address is available.

An advisory committee of the American Engineering Council with Dean Andrey A. Potter as chairman has drawn up the qualifications for inclusion in the volume.

It is hoped that all engineers coming within the following classifications will forward their data sheets promptly for publication in the coming volume. Qualifications are:

(*a*) Engineers of outstanding and acknowledged professional eminence.

(*b*) Engineers of at least ten years' active practice, at least five years of which have been in responsible charge of important engineering work.

(*c*) Teachers of engineering subjects in colleges or schools of accepted standing who have taught such subjects for at least ten years, at least five years of which have been in responsible charge of a major engineering course in such college or school.

Supplying the facts requested in the questionnaire will be a service to the profession.

F. M. Gibson, Secretary, 1937 Nominating Committee

THROUGH an error it was announced in the account of the A.S.M.E. Annual Meeting published in the January issue that B. E. Short of Austin, Texas, had been elected secretary of the Nominating Committee. It should have read F. M. Gibson, of Brooklyn, N. Y.

National Defense Meeting, Metropolitan Section

Address by Admiral Hobson on Feb. 9 to Be Broadcast

AN interesting discussion on national defense has been arranged by the Metropolitan Section of the A.S.M.E. to be held in the engineering auditorium of the Engineering Societies Building, New York, on February 9 at 8 p.m. The meeting will have as its distinguished guest and speaker Admiral Richmond P. Hobson, U.S.N., retired, who will disclose for the first time certain new developments which pertain to a new phase of national defense.

Admiral Hobson made a brilliant naval service record. He won international acclaim for his heroism, gallantry, and leadership in the Spanish-American War during which he commanded with a hundred per cent volunteer crew the United States collier *Merrimac* when it was taken under heavy fire into the harbor of Santiago de Cuba and deliberately sunk in the entrance channel thereby bottling up the Spanish fleet.

As a Representative in Congress from the State of Alabama from 1907 to 1915 Admiral Hobson foresaw the possibilities of aviation, even as the Wright brothers were making their first flight. Being taunted and subjected to derision by his colleagues for his apparently unfounded belief that air fleets were possible, he at that time replied, "I expect to see the day when great fleets will carry on in the air, and my hope shall be that America in that day will be in aviation the biggest and the best"

Following Admiral Hobson's address, which will be broadcast, two other distinguished high ranking military and naval officers will discuss other activities in the Department of National Defense.

P. T. Wetter Honor Guest at A.S.M.E. Luncheon

P. T. WETTER

A LUNCHEON in honor of Pierce T. Wetter, for 10 years a member of the staff of The American Society of Mechanical Engineers in charge of the activities of the professional divisions, was held at the Engineers' Club, New York, N. Y., on January 11. About 45 associates and friends of Mr. Wetter attended the luncheon to express their appreciation of his services to the Society and their best wishes for success in the new work he has undertaken. Mr. Wetter's resignation from his position with the Society was announced at the November 20 meeting of the A.S.M.E. Executive Committee.

Kenneth Condit, chairman of the Committee on Meetings and Program in 1936, presided.

Letters from friends and associates unable to be present were read, and informal tributes, expressions of regret at his leaving, and good wishes for his success in his new venture were acknowledged by Mr. Wetter in his response. Those who spoke for the A.S.M.E. activities Mr. Wetter had served were John Clyde Oswald, for the Graphic Arts Division, Clair B. Peck, former chairman of the Committee on Professional Divisions, C. E. Davies for the Society and the staff, and Crosby Field for the present committee on Professional Divisions. George B. Pegram, speaking for those present, presented a billfold and paid tribute in particular to Mr. Wetter's work for the Applied Mechanics Division.

Mr. Wetter became associated with the A.S.M.E. staff at a time when an active effort was being made to develop the special technical interests of a rapidly growing group of professional divisons. Upon his shoulders rested a large portion of the burden of program making for national meetings of the divisions, and of the details of the technical sessions of all Society meetings and of the secretarial services to the Committee on Professional Divisions and the executive committees of the individual divisions. In this work he won the friendship and esteem of hundreds of A.S.M.E. members engaged in these activities. His resignation, which takes effect February 1, makes it possible for him to take up a new line of work in charge of developing the American Cutting Alloys, Inc., in the manufacture and sale of cemented carbide titanium tips and cutting tools.

In his brief remarks Mr. Wetter assured his friends that his interest in the Society and the work of the professional divisions would continue. He may be reached at 500 Fifth Avenue, New York, N. Y.

A.S.M.E. Semi-Annual Meeting at Detroit, Mich.

Hotel Statler—Week of May 17

SIX KEYNOTE SESSIONS

Contributions of Automotive Engineering to Other Fields
Steel and Its Applications
Light-Weight High-Speed Trains
Management and Mass-Production Methods
Improved Methods of Fabrication
Summary of Week's Program with Its Implications

SIX MAJOR INSPECTION TOURS

To cover the automotive plants located in and near Detroit

TECHNICAL SESSIONS SPONSORED BY PROFESSIONAL DIVISIONS

Complimentary inspection tours will be run with the sessions

TECHNICAL COMMITTEE MEETINGS

With the Student Branches

Branch Doings

THE MEMBERS of the UNIVERSITY OF LOUISVILLE BRANCH listened to an entertaining talk on smoke abatement by Sabel Block and a paper by Richard Leins concerning the N.A.C.A. and its fourteen wind tunnels with wind velocities ranging from 60 to 500 miles per hour . . . . . . COOPER UNION BRANCH had a fine paper by James Brady on sheet metal, its manufacture and uses. Mr. Brady, in his discussion of the various manufacturing phases, also explained the simple calculations of the forces involved . . . . . . William Ryan of the IOWA STATE COLLEGE BRANCH gave a talk on steel fabrication plant operation . . . . . . The history and development of elevators up to the present time was ably presented by Frank Kesicke before the NOTRE DAME BRANCH . . . . . PRATT INSTITUTE (Aeronautics) BRANCH had an interesting debate on "In-Line Versus Radial-Type Aircraft Engines." Gordon Beckwith and F. A. Carlson spoke for the "In-Line" type and Jack Brookhart took the side of the Radial type. Jack was awarded the decision by the judges . . . . . . UNIVERSITY OF MISSOURI BRANCH members heard a paper by J. Louis Crum, Jr., on air conditioning . . . . . . At a UNIVERSITY OF NEBRASKA BRANCH meeting, Ward Tefft presented a very interesting paper on metallic heat insulation . . . . . . ARMOUR INSTITUTE BRANCH had members present papers under the same conditions and rules as are found at the annual district student conferences. Harold Nicholas spoke on tool reclaiming and Idris Thomas told of a trip to the West Coast. . . . Uel Jennings of the COLORADO STATE COLLEGE BRANCH spoke about automatic control in power plants . . . . . . The UNIVERSITY OF SOUTHERN CALIFORNIA BRANCH was given an actual demonstration on alternating-current welding during a talk on the subject by R. S. Farr . . . . . . BUCKNELL UNIVERSITY BRANCH listened to a talk by Millard Zimmerman on river coal and its market preparation . . . . . . PENNSYLVANIA BRANCH had Elmer Klapper give an illustrated lecture on bakelite. The lecture was so interesting that it was followed by a lively discussion among the members.

Trips and Inspections

One Saturday, members of the COLORADO STATE COLLEGE BRANCH inspected a power plant, a coal mine, and a municipal light plant . . . . . . ARMOUR BRANCH visited a steel foundry . . . . . . MISSOURI BRANCH went through a power plant . . . . . . AKRON BRANCH members drove 180 miles to make a four-hour visit to the Ford Motor Company at Dearborn, Michigan . . . . . . BROOKLYN POLY BRANCH is planning a trip during February to the city of brotherly love, Philadelphia, where the members expect to visit the Westinghouse Electric plant, the League Island Navy Yard, and the Budd Wheel Company . . . . . . OHIO STATE BRANCH made a trip to the Battelle Institute . . . . . . CLEMSON BRANCH made inspection tours to a laundry, a water-turbine power plant, and the Duncan power plant.

Interesting Talks by Outsiders

Our most sincere thanks to Dr. Felix Isermann from Germany. During the last few months he has spoken before many student branches about the latest developments of machinery and machine tools in Germany.

He has concluded his talks by showing motion pictures of machines being operated at the Leipzig Trade Fair...... Among the branches fortunate in listening to Dr. Isermann were NEW YORK UNIVERSITY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, COOPER UNION, PENNSYLVANIA STATE COLLEGE and RENSSELAER POLYTECHNIC ...... The UNIVERSITY OF MISSOURI BRANCH had Maxwell C. Maxwell of the Yale and Towne Lock Company give an interesting talk on locks..... STEVENS BRANCH had a very instructive and entertaining lecture on the subject of photoelasticity by Prof. R. F. Deimel of the mechanical-engineering department ...... NEWARK COLLEGE BRANCH, as part of its program of interesting meetings, had Lee D. Warrander speak on the latest developments in aviation, namely, engine design, variable-pitch propellers, radio beams and supercharging ...... C.C.N.Y. BRANCH listened to a talk by A. S. Rairden on wire rope, its manufacture, and uses ...... J. E. McBride gave an illustrated lecture before the UNIVERSITY OF MICHIGAN BRANCH membership on material-handling devices.

This and That

VERMONT BRANCH presented a movie on the making of a V-8 engine. The film was obtained through the U. S. Department of the Interior, Bureau of Mines. The large attendance at the meeting was a successful culmination of the efforts of the branch to publicize its activities and educational value to the school, the students, the faculty and the townsfolk ...... SWARTHMORE BRANCH reports a 400 per cent increase in membership over last year. This phenomenal growth is due to the fine work of such live-wire members as John Beck, chairman of the branch and Olive Hendrichs, secretary-treasurer and their aim to make meetings interesting by having each member take an active part by presenting several papers during the year on technical and related subjects. ...... C.C.N.Y. BRANCH through Professor Bischof, honorary chairman, will award a prize of $10 to the member giving the best 15-minute paper before March 1, 1937...... NEW HAMPSHIRE BRANCH members recently elected Fred Johnson to the important office of corresponding secretary. Fred promises to keep us well supplied with plenty of news about his branch's doings...... Our congratulations to William Cramer, chairman of the LEWIS INSTITUTE BRANCH, on his election to the presidency of the senior class.

Metropolitan Junior Group to Meet With Students

THE Student Branches of the Metropolitan area and the Junior Group of the Metropolitan Section of the A.S.M.E. plan an informal smoker for Tuesday, February 23, at Cooper Union. The meeting will be held in room 205 at 7:30 p.m., under the chairmanship of Cornelius S. Kirby of Cooper Union.

It is intended further to acquaint the student branches with each other and with members of the Junior Group. Students will attend from Columbia, C.C.N.Y., Brooklyn Poly., Stevens Tech., N.Y.U., Newark College of Engineering, Pratt Institute, and Cooper Union. Each of the schools will have one of its members speak on some item of interest concerning its particular branch. Members of the Junior Group will discuss the activities of that body with relation to the branches.

Talks will be brief and of such a nature as to demand interest. A pleasant social evening is anticipated. This program is another in the series sponsored by the Junior Group of the Metropolitan Section to assist the student and young engineer soon to be members of the A.S.M.E.

L. B. Stinson, Student-Prize Winner, Impressed With 1936 Annual Meeting

ON Honors Night, at the 1936 Annual Meeting of The American Society of Mechanical Engineers, as reported in the January issue, page 26, Leon B. Stinson, of the Oklahoma Agricultural and Mechanical College, received the Undergraduate Student Award for his paper "Polymerized Motor Fuels, Their Economic Significance." Mr. Stinson came to New York to attend the meeting and to receive the award. Upon his return to college, he wrote a letter of appreciation to the Society from which the following excerpts have been taken as illustrative of his impressions of the meeting and its value.

"I was indeed delighted to represent Oklahoma A. and M. College at the meeting, and may I say that it was an experience which I sincerely wish could have been shared with me by many more students from over the country.

"Particularly was I impressed with the fact that engineers of the greatest repute, loathe as we are to accept it, are approaching inactivity due to age, and that we of the present student branches will be expected soon to accept their responsibilities and carry on the tasks that they in their turn received from their elders. Especially do we have stores to gain from their acquaintance; much to profit by their knowledge and experience. In that manner The American Society of Mechanical Engineers is performing a very valuable function for student engineers through its student branches. Perhaps not of equal value, but we may be assured of very great value, is the opportunity afforded for self-expression and for social and professional contact to students by the society. Certainly these justify the maintenance of a student program which I am convinced is of such value that the students who do not participate are tremendously the losers.

"I wish that I might encourage more students to participate in the activities of A.S.M.E. for theirs is certainly the benefit and the opportunity of valuable acquaintances, splendid training and experience, and a wealth of helpful information.

"We at Oklahoma A. and M. are indeed favored in having a very active student branch which holds regular meetings of instructive and constructive nature under the able leadership of Mr. V. W. Young as honorary chairman and Mr. Vane Brant as chairman. Our membership has almost doubled in the past year and we look forward with pleasant anticipation to the meeting of the student branches of our district on our campus in the spring."

Johns Hopkins Engineering School to Celebrate Its 25th Anniversary

A THREE-DAY program including an extensive exhibit of recent advances in applied engineering and technical sessions for the discussion of research problems will celebrate the twenty-fifth anniversary of the Johns Hopkins School of Engineering next month. The principal event will be an address at the sixty-first Commemoration Day exercises of the University on February 22 by Dr. Carl T. Compton, president of the Massachusetts Institute of Technology. Dr. Compton is a member of the A.S.M.E.

The program will conclude with the annual alumni dinner on the evening of the twenty-second, when Abel Wolman, Hopkins alumnus, will deliver the main address. Mr. Wolman is chief engineer of the Maryland State Department of Health, chairman of the State Planning Commission and of the Water Resources Committee of the National Resources Committee, and a widely known lecturer, author, and consultant in sanitary engineering.

Engineering Buildings Open for Inspection

On the evening of February 19 the engineering buildings on the Homewood campus will be open for inspection and will at the same time be the scene of a carefully prepared display of many technical materials and processes in the forefront of research activity today. In the field of mechanical engineering it is planned to show for the first time a novel form of bearing based on pure fluid lubrication, and to demonstrate in a specially constructed apparatus the physical changes of steam in a turbine nozzle.

Experiments with domestic oil-burner equipment, a current project in the laboratories, are to be in progress, and the most recent mechanical systems used in air conditioning, steam-vapor jet refrigeration, and automotive Diesel power will be on view. Tests on engines, fuels, materials, and instruments will be run as an example of routine student instruction.

Honorary Degrees to Be Presented

Honorary degrees are to be presented to a few distinguished engineers at the Commemoration Day exercises. The conference sessions on Saturday morning, February 20, will be attended by officials of the city and state, prominent engineers from other colleges and leading industrial engineers. Members of the faculty of the Johns Hopkins School will read papers on special problems, which will also receive recognition in the other branches of the exhibit.

Additional points of interest in the exhibit will be the tests of the dielectric properties of

oil-insulated papers; a demonstration of the effect of lightning upon power-transmission lines; the magnetic investigation of electric welds; the melting of soft metals by immersion burners; the operation of the hydraulics-laboratory equipment; the industrial adaptation of the photoelectric cell for counting units of output on a production line; and a device for testing the ability of automobile drivers, which may be used by visitors to the show.

The School's Founders

The Johns Hopkins School had as its three founding professors Dr. J. B. Whitehead, the present dean of the School; Dr. Carl Clapp Thomas, now vice-president of the Dwight P. Robinson Company; and Dr. Charles J. Tilden, now professor of engineering mechanics at Yale School of Engineering. In the early years these men, unhampered by outworn traditions of instruction or by antiquated equipment, quickly established standards of advanced teaching and research which ably represented the pioneering spirit of Johns Hopkins. In the intervening period the School has made important contributions to technical science.

U.S.A. Precision-Instrument Laboratory at N.Y.U.

THORNDIKE SAVILLE, dean of the New York University College of Engineering, has announced that the Ordnance Department of the U. S. Army would very soon establish a precision-gage instrument laboratory for the Metropolitan area.

The gage laboratory, the only one of its kind in that area, will be used in the testing of various tools, instruments, mechanisms, and other equipment for military purposes. It will be available also to students of engineering, and others, for general research purposes.

Instruments, capable of measurements to the millionth of an inch, will be certified by the U. S. Bureau of Standards before their installation. "Government equipment will provide unusual opportunities to the faculty, students, and industry generally where gages and precision measurements are essential," Dean Saville said. "It is a distinct honor to the University to be selected for this station and the advantages to the College of Engineering are manifold."

Second International Congress for Testing Materials, London, April 19–24, 1937

PRELIMINARY notice has been received of the Second International Congress of the International Association for Testing Materials, to be held in London, April 19–24, 1937.

Participation in the congress, according to the announcement, is open to all interested on payment of the membership fee.

Subjects for discussion at the congress are divided into four groups dealing with metals, inorganic materials, organic materials, and subjects of general importance.

Other Engineering Activities

American Management Association Calls Meeting on National Labor Problems

Conference Expected to Have Settling Effect on Present Crisis

WITH labor crises developing rapidly on a nation-wide front, the American Management Association today issued a call to 2182 companies in its membership and to industry at large to attend a conference in Philadelphia on February 9 to 11. It is expected that from this conference will emerge plans and policies which will have a settling effect on the chaotic conditions now existing in a number of the country's major industries.

Committees from the Association, directed by Thomas G. Spates, director of industrial relations of General Foods Corporation, have been preparing the program, which will be staged with the cooperation of the Philadelphia Chamber of Commerce and the Philadelphia Personnel Association at the Benjamin Franklin Hotel.

Among those who will make reports and recommendations on personnel policies and procedures are: Virgil Jordan, president of the National Industrial Conference Board; Edgar J. Kaufmann, Kaufmann Department Stores, Inc.; Eric A. Nicol, manager of personnel, Philadelphia Gas Works Company; Clarence G. Stoll, member A.S.M.E., vice-president, Western Electric Company, Inc.; J. W. Dietz, superintendent of industrial relations, Western Electric Company, Inc., Kearny; W. H. Winans, industrial relations department, Union Carbide Company; C. S. Ching, United States Rubber Company.

The Association advised its members that the conference would be conducted largely on a laboratory basis, with discussion of specific employer-employee situations. Among the subjects that will come under discussion are: the formulation of labor policy; employee representation; trade union agreements; technique of wage negotiations; problems of personnel administration in connection with social security; the development of executive ability in a business organization; and others of a similar nature.

A.F.A. Announces Organization Change

AS THE first step in a program of broadening both its scope of activities and its responsibilities as a National Association of the Foundry Industry, the executive committee of the board of directors of the American Foundrymen's Association, at a meeting held in Chicago, December 4, elected C. E. Hoyt, for the past 18 years executive secretary-treasurer, to the position of executive vice-president in accordance with the recent revision of the By-Laws creating the office of Executive Vice-President.

At the same meeting, Dan M. Avey, formerly vice-president and director of the Penton Publishing Company and editor of *The Foundry*, was elected secretary-treasurer, effective January 1, 1937.

In his new position, Mr. Hoyt will continue as the executive officer of the Association, directing efforts toward broadening the field of service of the A.F.A.

Milwaukee has been selected for the 41st annual convention and exposition of the American Foundrymen's Association, to be held during the week of May 2, 1937. The meetings and display of equipment and supplies will be staged in the Milwaukee Auditorium.

Physics Institute to Hold Series of Technical Conferences

FOLLOWING the five-year anniversary meeting, held in New York last October, at which was presented a broad survey of the industrial applications of physics, the American Institute of Physics has decided to hold a series of technical conferences each devoted to a single important field of application. They will be held in various localities where there exist institutions active in research in the respective fields. The first of these, on metals, particularly steel, will be held at, and with the joint sponsorship of, the Massachusetts Institute of Technology, on January 28 and 29.

Some of the more general papers to be presented at this first conference are: "Research Problems in the Steel Industry," by E. C. Bain, United States Steel Corporation; "Inclusions in Ferrous Alloys," by A. B. Kinzel, Union Carbide and Carbon Company; "Flow Phenomena in Heavily Stressed Metals," by P. W. Bridgman, of Harvard; "Electronic Structures in Metals and Alloys," by J. C. Slater, of M.I.T.; "Corrosion," by J. R. Burns, of the Bell Laboratories; "Elastic Properties of Ferrous Alloys," by A. V. de Forest, of M.I.T.; and "Chromium-Nickel-Iron Alloys," discussed by Dr. V. N. Krivobok, of the Allegheny Steel Company.

Subjects under consideration for later conferences are biophysics, research in the textile industry, applied electronics, production and applications of low temperatures, nonferrous metals and alloys, meterology, etc.

The principal purpose of the conferences is to serve technical men and industrial corporations in their efforts to improve their services in these fields.

Committee on Professional Recognition Reports to E.C.P.D.

Recommendations for Correlating Methods of Formal Recognition of the Development of an Engineer

AT THE annual meeting of the Engineers' Council for Professional Development held on October 6, 1936, the Committee on Professional Recognition presented a tentative annual report. The Council deferred official action on the recommendations contained in the report until further consideration might be given them at a future meeting. The complete report of the Committee follows:

To the Committee on Professional Recognition is assigned the fourth phase of the E.C.P.D. program, namely, to develop procedure and recommendations for "bringing some correlation into the various methods of formal recognition of the development of an engineer" (page 3 of the 1935 Report of the Engineers' Council for Professional Development.)

The present avenues or stages of formal recognition of the development of an engineer are three in number. They are all represented in E.C.P.D. as a coordinating agency. Listed in order of progressive and chronological sequence, they are:

1 *Professional Education*, as evidenced generally by graduation from an approved college of engineering.

2 *Registration as a Professional Engineer*, representing legal recognition and admission into the engineering profession.

3 *Membership in a Professional Grade of a Recognized Engineering Society*, representing recognition of the attainments of the individual by his fellow engineers.

These three stages of formal recognition of the development of an engineer are now established. Our problem is to improve their correlation.

The proposal of any additional procedure of certification or recognition would only be adding a fourth method to the three methods of progressive recognition already established. It would introduce new competition or conflict and new difficulties of correlation, and would therefore not be a solution of the problem of harmonious coordination.

It is true that the three methods of progressive recognition already established are not yet, within themselves, sufficiently uniform. With equal interest in all three, E.C.P.D. should address itself to achieving results of more uniform significance. Nothing in this report is to be construed as recommending any lowering of present standards or requirements.

1 Under the heading of *Professional Education*, E.C.P.D. (through its Committee on Engineering Schools) is seeking to establish recognized national standards of quality and attainment for engineering schools through its program of accrediting. "Graduation from an approved course in engineering" should eventually have a more definite and more uniform significance.

2 Under the heading of *Engineers' Registration*, it is recognized that this method of formal recognition is not yet universal or sufficiently uniform. Only 35 of the 48 states have engineers' registration laws, and in three of these states the laws are incomplete, covering only a fraction of the profession. Moreover, with such laws enacted at different dates (since 1907) and under varying circumstances, there are naturally some variations in their qualification requirements. "E.C.P.D. should therefore address itself to rendering all possible assistance to effect uniform registration laws in states which do not have them, to improving the registration laws that now exist, and to effecting among these present laws a higher degree of uniformity as to requirements and as to form of recognition." (1935 Report of Committee on Professional Recognition, adopted by E.C.P.D. October 8, 1935.)

3 Under the heading of *Membership in Engineering Societies*, it is recognized that there is considerable variation in qualification requirements for admission to the same or corresponding grades of membership in the various national organizations. Significance and recognition will be advanced if these requirements are brought to a more uniform level, both in constitutional prescription and in application. E.C.P.D. has adopted the recommendations of this Committee (1933 and 1934) for "Standard Grades of Membership," namely Student Member, Junior Member, Member, and Fellow; and support should be given to the establishment of this uniform system of grades upon the basis of the advantages to the entire engineering profession resulting from more uniform formal recognition. E.C.P.D. has also adopted the "Minimum Definition of an Engineer" formulated by this Committee (1933); and under the approved "Standard Grades of Membership," the grade of Member is defined as "The full-fledged engineer, that is, the engineer who has passed the requirements in the minimum definition of an engineer." All of the interested engineering societies should therefore be urged to make the "Minimum Definition of an Engineer" their goal as a minimum requirement for admission to the "Member" grade. The "Minimum Definition" prescribes professional education, specified experience, and the passing of written examinations. Instead of duplicating such examinations, the engineering societies may accept the results of corresponding examinations, passed in securing professional registration under the state laws.

Correlation

If the three avenues or stages of recognition of development of an engineer (1, Education; 2, Registration; 3, Membership) are appreciated as logically progressive and successive, much apparent conflict is resolved, and consistent correlated relationship is made manifest. The Committee on Student Selection and Guidance has for its province the problems preceding and anticipatory to Phase 1; the Committee on Engineering Schools covers Phase 1, the Committee on Professional Training is chiefly concerned with the problems covering the period of individual development between Phase 1 and Phase 2, and beyond; and the Committee on Professional Recognition is concerned with all as they are related to the recognition of the engineer.

Under the concept of the progressive sequence of the three stages of recognition (1, Education; 2, Registration; 3, Membership) each successive stage should be predicated, so far as practicable, upon the prior attainment or completion of the stage preceding it. Thus will any remaining conflict be minimized, and correlation improved.

Accordingly, evidence of completion of (1) professional education (by graduation and/or examinations) should be made universally a prerequisite for (2) registration under the state laws and for (3) admission to Member grade in the national engineering societies. E.C.P.D. should therefore give its assistance in amending any state registration law in which evidence of professional education (by graduation and/or examinations) is not yet clearly specified as an essential prerequisite. Likewise E.C.P.D. should urge all interested engineering societies to adjust their requirements so as to specify evidence of professional education (by graduation and/or examinations) as an essential prerequisite for membership.

Similarly, to improve correlation, registration should be made so far as practicable, a minimum prerequisite for admission to the professional grades[1] of membership of the national engineering societies. Each organization can easily determine for itself which of its membership grades shall be regarded as professional. For admission to the professional grades of membership, with such temporary exceptions as may be practically indicated, state registration should be established as a minimum requirement. This does not mean that any candidate is to be accepted for membership merely because he is registered or licensed. The engineering society may not yet be satisfied with the qualification requirements for registration in some of the states, and may desire therefore to impose such additional requirements as it deems

[1] Professional grades of membership include: Honorary Member, Member, and Associate Member of the American Society of Chemical Engineers; Honorary Member, Fellow, Member of the American Institute of Electrical Engineers; Honorary Member, Fellow, Member of The American Society of Mechanical Engineers; Honorary Member, Member of the American Institute of Mining and Metallurgical Engineers; Active Member of the American Institute of Chemical Engineers

proper. State registration is here recommended as a desirable basic requirement, not as an all-sufficient requirement.

Unless any engineering society takes the position that the states maintain qualification requirements higher than should be expected of professional grades of membership of the society, there would appear to be no valid objection to requiring registration as a prerequisite. If, on the other hand, any engineering society takes the position that the registration requirements in any state are inferior, there would appear to be no objection to challenging any candidate who fails even to meet such inferior requirements.

Exceptions can of course be made for applicants from the 13 states which do not yet have registration laws, or from the 3 states in which the registration laws are incomplete. Exceptions can also be made for applicants who can show specific exemptions in their state registration laws, permitting their continued responsible practice of engineering without registration.

It is therefore recommended that the interested engineering societies consider the eventual adoption of the following requirement:

"Before admission or transfer to professional grades of membership in this Society, an applicant shall show that he is or has been a legally registered professional engineer, unless he resides in a state in which an engineers' registration law has not been enacted, or unless he shows specific legal exemption under the engineers' registration law of the state in which he resides, permitting him to engage in the responsible practice of professional engineering without registration."

The adoption of this recommendation will improve correlation between membership grades and professional registration. It will also improve correlation between recognized professional status and corresponding grades of membership in the different engineering societies. It will, incidentally, facilitate the full establishment and application of the Minimum Definition of an Engineer as a requirement for admission to Membership. Such coordination of (2) Registration and (3) Membership will improve the standards and status of both and will be a constructive contribution toward harmonious and consistent relationship of the "various methods of formal recognition of the development of an engineer."

A further contribution to the correlation and significance of formal recognition would be to simplify, toward greater uniformity, the wide variation of degrees conferred upon graduation from engineering schools and, in particular, to eliminate the professional degree (C.E., M.E., E.E., etc.) as a degree in course. For perfect correlation, E.C.P.D. should recommend that these professional degrees, if conferred at all, be not conferred by the engineering schools upon any graduate before he has passed the stage of professional registration. Again, registration should be regarded as a necessary, though not as a sufficient, prerequisite. Each individual school may impose such additional requirements and tests as it deems appropriate.

Survey of Present Correlation

In order to establish an index of the present degree of correlation between (2) state registration and (3) society membership, a survey has been prepared under the auspices of E.C.P.D. at the request of the Committee on Professional Recognition. This survey, in summary form, yields the percentages of correlation given in Table 1.

TABLE 1 PERCENTAGE OF MEMBERS REGISTERED AS PROFESSIONAL ENGINEERS IN 30 REGISTRATION STATES

A.S.C.E. Grade	Per cent		A.S.M.E. Grade	Per cent	A.I.E.E. Grade	Per cent	A.I.M.E. Grade	Per cent	A.I.Ch.E. Grade	Per cent
Assoc. M.	54		Members		Members		Members	13	Active M.	11
Members	56	56	Fellows	25	Fellows	29	Hon. M.			
Hon. M.	60		Hon. M.		Hon. M.					
Juniors	15	15	Juniors	04	Juniors	07	Juniors	02	Juniors	05
Affiliates	16		Associates		Associates		Associates		Associates	

The complete report of this count, by states, of the relative number of members registered under the state laws in each grade of membership in each of the five participating engineering societies, is submitted as an appendix to this report.[2] These data are also shown in graphic form for New York, for Iowa, and for 30 states for which registration figures were available.

The percentages of correlation found in this survey are higher than was generally anticipated. They are higher for some of the societies than for others. By this survey, a clear line of differentiation is indicated between the professional grades, and the other grades.

An improvement in the indicated percentages of correlation is to be desired for advancing the recognition of the profession. The development of recommendations for the improvement of such correlation is a phase of the E.C.P.D. program assigned to the Committee on Professional Recognition.

Summary of Recommendations

1 E.C.P.D. should urge upon its participating engineering societies the actual adoption and application of the "Minimum Definition of an Engineer" as a minimum requirement for admission to membership. Evidence of professional education (by graduation and/or examinations) should be specifically included in the prescribed membership qualifications.

2 E.C.P.D. should urge and encourage the early adjustment of membership grades in the participating engineering societies to conform to the "Standard Grades of Membership" previously formulated and ratified.

3 E.C.P.D. and its participating bodies should render all possible assistance to effect uniform registration laws in states which do not have them, to improve and to strengthen the registration laws where they now exist, and to effect among these present laws a higher degree of uniformity as to requirements and as to form of recognition.

4 E.C.P.D. should give its assistance and support in amending any state registration law in which evidence of professional education (by graduation and/or examinations) is not yet clearly specified as an essential prerequisite.

5 E.C.P.D. should recommend to all participating and interested engineering societies that state registration of a candidate be established as a minimum prerequisite for admission to professional grades of membership, with such provisional exceptions as present circumstances may justify.

6 E.C.P.D. should urge and support the simplification, toward greater uniformity, of the wide variations of degrees conferred upon graduation from engineering schools.

7 E.C.P.D. should recommend to all engineering schools that the professional degree be eliminated as a degree in course; and that (when it is awarded for post-collegiate professional recognition), it be not conferred until after the candidate has secured professional registration as a minimum prerequisite.

Respectfully submitted,

C. N. LAUER, *Chairman* F. M. BECKET
J. W. BARKER F. L. BISHOP
H. C. PARMELEE (H. S. Rogers, Alternate)
D. B. STEINMAN J. P. H. Perry

Committee on Professional Recognition

[2] The Appendix is not included with this report.

A.S.T.M. Atmospheric-Corrosion Tests on Wire

IN THE country-wide series of atmospheric-corrosion tests of wire and wire products, being carried out by the American Society for Testing Materials, with its Committee A-5 on Corrosion of Iron and Steel in direct charge of the work, there are almost eleven thousand (10,886 to be exact) test specimens involved. The specimens of plain unfabricated wire, barbed wire, wire strand, farm fence, and chain-link fence have been assembled at several of the eleven test sites and the remainder will be completed within the next few weeks. There are involved in the tests about six miles of plain wire, over a mile of barbed wire, about one-half mile of strand, about two miles of farm fence, and one-third mile of chain-link fence.

This vast research program has two major objectives: (1) To obtain essential engineering information concerning the materials involved and (2) to assist in establishing national standard specifications for fencing, barbed wire and the other products which will afford consumers an adequate guide in purchasing the materials.

The present wire-test program has been preceded by extensive long-time atmospheric-corrosion studies involving bare (uncoated)

(Continued on page 138)

NOW

for the first time

PROCESS CONTROL CAN BE COORDINATED AUTOMATICALLY

AFTER the laboratory and the production executive have determined the processing formula or specifications by which a product is to be made, after they have set up the optimum conditions both for such variables as temperature, pressure, flow, humidity, and for such mechanical operations as the opening and closing of valves, the starting and stopping of blowers or motors, then comes the big problem.

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One plant reports that "Bristol's System of Coordinated Process Control increased production 100% without additional labor or working overtime."

Another says "With the plant operating at its rated capacity . . . the net profit will be sufficient to pay for the complete installation in considerably less than one year."

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From another user, "The distinctive feature of this plant is completely automatic operation and control. The attendant starts up the apparatus at the beginning of the day and turns it off at the end of the shift in the evening. During the operating period . . . no attendance is required."

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iron and steel sheets and metallic coatings on various shapes. The first named tests, begun in 1916, involved iron and steel sheets of varying composition, and included observation of corrosion in various types of atmosphere (rural, industrial, salt air) and by immersion in various kinds of water (city, mine, saline).[1] These tests so clearly demonstrated the value of long-time corrosion tests, conducted upon a cooperative basis by producer and consumer under the auspices of a neutral, impartial body, that Committee A-5 planned a similar study of metallic coatings, principally of zinc but including also cadmium, aluminum, lead and copper, on (1) iron and steel sheets, (2) shapes, hardware, and tubular goods, and (3) wire and wire products exposed to different types of atmosphere. The first two parts of the investigation were started, respectively, in 1925 and 1929; the third part is now beginning.

Exhibition of Scientific Photography to Be Held

AN International Exhibition of Applied and Scientific Photography will be held in Rochester in March, 1937, under the sponsorship of the Rochester Scientific and Technical Section of the Photographic Society of America. The objective of the exhibition will be to show examples of the application of photography to the various branches of science and technology.

Photographs or apparatus showing the applications of photography to typical problems in any branch of science and technology, will be welcomed. All correspondence in regard to the Exhibition, or requests for entry blanks should be addressed to the Secretary, C. B. Neblette, F.R.P.S., Department of Photographic Technology, Rochester Athenaeum and Mechanics Institute, Rochester, New York.

Dr. Jakob to Head Research Laboratory at Armour

MEMBERS of the A.S.M.E. will be interested to learn that Dr. Max Jakob, who until January 1, 1936, was connected with the Physicalisch-Technischer Reichstalt, Berlin, Germany, has been appointed director of the recently established research laboratory of Armour Institute of Technology in Chicago.

Dr. Jakob's name has been a familiar one to students of thermodynamics for the past quarter century in connection with investigations in the thermal and physical properties of steam. After his lecture tour of this country last summer he left behind him the manuscript copy of his six lectures which were published in the October and November, 1936, issues of MECHANICAL ENGINEERING.

[1] The results of these tests have been fully reported in the annual Proceedings of A.S.T.M. from 1916 on. Parts of the investigation are still current. See 1936 report of Committee A-5, Proceedings, American Society for Testing Materials, vol. 36, part I.

1937 Awards of American Institute, City of New York

TWO Awards of the American Institute of the City of New York for 1937, a Gold Medal to the Bell Telephone Laboratories, and a Fellowship to Watson Davis, director of Science Service, have been announced by Gerald Wendt, director of the Institute. The awards will be presented at a meeting of the Institute to be held February 4, 1937.

The gold medal, given annually by the American Institute in recognition of outstanding accomplishment in research, was awarded to the Bell Telephone Laboratories "for researches in electrical science which, applied to communication, have promoted understanding, security and commerce among peoples by transmitting human thought instantly throughout the world." The award will be received in the name of the more than four thousand men and women of the Bell Telephone Laboratories by Dr. F. B. Jewett, its president.

The Fellowship in the Institute, conferred for outstanding service in the interpretation of science to laymen, was awarded to Mr. Davis "for interpreting to the people of the nation the rapid progress of science upon which modern civilization depends and for the organized dissemination of research findings as news."

The American Institute of the City of New York was incorporated in 1828 for the purpose of "encouraging and promoting domestic industry in this State and in the United States." Its membership includes leading scientists and others interested in promoting this aim.

Membership Dues As a Business Expense Not Taxable

Members of The American Society of Mechanical Engineers engaged in professional work are reminded that their membership dues, as a business expense, are ordinarily deductible in arriving at their taxable net income.

Appraisal Executives Adopt Basic Standards of Practice

THE Association of Appraisal Executives, of Washington, D. C., following a three-year study, has formulated and adopted basic standards of appraisal practice and procedure and of accepted definitions of certain commonly used appraisal terms, and has embodied them in a pamphlet, entitled "Basic Standards of Appraisal Practice and Procedure."

Under the heading "Principles of Valuation" the pamphlet describes concepts and bases of value, and sets forth that the main goal of an appraisal is the determination of "Value for Use."

There are included about 100 definitions of terms frequently found in appraisal reports.

The publication discusses the elements of original and historical cost, trended cost, cost of reproduction new; considers depreciation problems and methods of valuation.

Manufacturers of Cast-Iron Soil Pipe Prepare to Supply American Standard, Effective 1937

THE American Standard for Cast-Iron Soil Pipe and Fittings (A40.1-1935) was endorsed at a meeting of the manufacturers of this product held in Cincinnati on December 5, 1936, with adoption of the following resolution calling for the supply of the product on and after that date in conformity with the new standard:

WHEREAS, In August, 1928, the Sectional Committee for Standardization of Plumbing Equipment, sponsored by the American Society of Sanitary Engineering and The American Society of Mechanical Engineers, was requested to form a Committee for the purpose of preparing an American Standard Specification for cast-iron soil pipe and soil-pipe fittings, and,

WHEREAS, This Committee was appointed in January, 1931, and the Standard Specifications as formulated was widely distributed for opinion and comment, in October, 1933, and was voted approval by the Sectional Committee, the two sponsor bodies, and was finally approved by the American Standards Association, October, 1935.

Therefore be it resolved, That the Soil Pipe Manufacturers of the United States in Assembly, December 5th at Cincinnati, Ohio, do ratify and adopt, the American Standard Specifications and that a communication for record be sent to the American Standards Association in that on and after January 1, 1937, the manufacture of soil pipe and fittings will be in conformity with the above American Standard Specifications.

W. A. BRAELET, *Vice-President*
I. W. ROUZER, *Secretary*

Although cast-iron soil pipe and fittings have been in general use throughout the country for a long time, it was not until 1931 that a nationwide effort to formulate a national standard for this product was made with the organization in January of that year of Subcommittee No. 8 of the Sectional Committee on Minimum Requirements for Plumbing and Standardization of Plumbing Equipment.

During the next four years the subcommittee made intensive studies of the best practice in the United States and distributed numerous questionnaires and tentative drafts of its report broadly for criticism and comment.

The final draft was completed in April, 1935, and, following approval by the sectional committee, the A.S.S.E., and the A.S.M.E., it was finally approved by the American Standards Association in October, 1935.

(*Continued on page 140*)

DO YOU KNOW..

IT COSTS MORE TO REPACK A PUMP THAN THE PRICE OF THE PACKING ITSELF

Experience has shown that the labor charge, the time wasted, the stoppage of production, far outweigh the actual cost of the packing.

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the packing made to withstand high temperatures and so perfectly lubricated as not to harden in service. "Palmetto" gives very long service under these conditions.

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and MINE PUMPS

Admiral Rock Made Fellow Institution of Engineers, Shipbuilders

HONORARY Fellowship in The North East Coast Institution of Engineers and Shipbuilders has been conferred upon Admiral G. H. Rock (CC) U.S.N. (ret.), president of the Society of Naval Architects and Marine Engineers.

This honor was conferred as a recognition of Admiral Rock's eminence as a naval architect, for his services to the United States Navy, and as an expression of appreciation for the hospitality shown the Institution at the international meeting of naval architects and marine engineers held last September.

Tell Berna New Manager Machine Tool Builders

C. R. BURT, president of the National Machine Tool Builders' Association announces the appointment of Tell Berna of Cleveland, Ohio, as general manager of the Association from January 4. Mr. Berna is a graduate of Cornell University with a degree of M.E. He has been general sales manager of The National Acme Company of Cleveland for the past six years. He succeeds Herman H. Lind who is now executive vice-president of the American Institute of Bolt, Nut, and Rivet Manufacturers.

Local Sections

Coming Meetings

Baltimore: February 11. Maryland Hall, Johns Hopkins University at 8:15 p.m. Subject: "The Development of Crown Caps and Enclosures, Glass Containers, and the New Steel Mill of the Crown, Cork and Seal Company," by Messrs. William Cooper, assistant chief engineer, and Matthew Schon, manager of the steel mill division, Crown, Cork and Seal Company. An inspection trip to the Company plant will be made on the following day.

Birmingham: February 25, 26, 27. Fifth joint foundry practice meeting of The American Society of Mechanical Engineers and the American Foundrymen's Association to be held at the Tutwiler Hotel, Birmingham, Ala. The meeting this year will deal with safety, hygiene, and equipment for foundries, rather than strictly metallurgical problems.

Central Indiana: February 16. Lincoln Hotel, Indianapolis, Ind. All-day joint meeting with the Indiana Engineering Society, the American Institute of Electrical Engineers, and the American Society of Civil Engineers.

Charlotte: February 12. Charlotte Hotel, Charlotte, N. C. Subject: "Transportation Problems of the South," covered by J. Haden Alldredge, transportation economist of the Tennessee Valley Authority, Knoxville, Tenn.

Hartford: February 18. Hartford Electric Light Co. Auditorium, 266 Pearl St., Hartford, Conn., at 8:00 p.m. Subject: "Present and Future Problems in Air-Conditioning Economics," by W. H. Carrier, chairman of the Board of Directors, Carrier Corporation.

Ontario: February 11. Oak Room, Union Station, Toronto, Ont., Canada, at 8:00 p.m. Subject: "The Economic Side of Engineering," by Prof. C. R. Young, University of Toronto.

Philadelphia: February 23. Engineers' Club, 1317 Spruce St., Philadelphia, at 8:00 p.m. Yearly student meeting. Subject: "The Use of Models to Illustrate Complicated Mechanical Problems," by Dr. J. P. Den Hartog of Harvard University.

Schenectady: February 18. General Electric Company, Rice Hall, Schenectady, N. Y. Junior Discussion Meeting. Subject: "The Organization of Engineers." The meeting will be under the chairmanship of J. E. Ryan.

Washington, D. C. February 11. Potomac Electric Power Company Auditorium at 8:00 p.m. Subject: "Bus Bar to Lamp Socket," by George Bisset, assistant superintendent substation department, Potomac Electric Power Company.

Waterbury: February 18. Elton Hotel, Waterbury, Conn. Subject: "Measuring Executive Characteristics," by Prof. Johnson O'Connor of Stevens Institute of Technology.

Worcester: February 9. Sanford Riley Hall, Worcester Polytechnic Institute, at 7:30 p.m. Subject: "Occupational Diseases—Is Silicosis a Racket?"

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after February 25, 1937, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

NEW APPLICATIONS

Andresen, Wm. A., Chicago, Ill.
Bentley, Clyde E., Berkeley, Calif.
Bickel, L. A., Dallas, Tex.
Clark, Joseph P., Morrisville, Pa.
Cody, Clifford S., Springfield, Mass.
Cotter, Chester, North Kansas City, Mo.
Davis, L. M., Holtwood, Pa.
Decker, Lewis M., Baton Rouge, La.
Engel, R. A., Marshalltown, Iowa
Floyd, Edwin C., San Mateo, Calif.
Glas, Anatol, San Francisco, Calif.
Hartsig, Albert L., Jr., Jersey City, N. J.
Haydock, Walter C., Jr., Brookline, Pa.
Hazen, Joseph, Sunnyside, L. I., N. Y.
Helbig, Robert W., Oak Park, Ill. (Re)
Henry, Howard J., Grand Forks, N. D.
Herzog, John H., Burlingame, Calif.
Highum, Orvie, Grand Forks, N. D.
Hori, Yasuo, New York, N. Y.
Kendall, Harry T., Los Angeles, Calif.
Knight, Floyd C., Cleveland, Ohio
Kudla, Stephen, Beloit, Wis.
Linn, F. C., Swampscott, Mass.
Lovell, A. W., Phila., Pa. (Rt & T)
Otocka, Edw. A., Hoboken, N. J.
Parsons, Geo. E., Detroit, Mich.
Robertson, A. M., Bloomfield, N. J.
Sailliard, John H., Great Kills, S. I., N. Y.
Seck, Chas. F., Annville Ky. (Re)
Sheppard, Geo. W., Minneapolis, Minn.
Sonobe, Tsukasa, New York, N. Y.
Stevens, Martin Lewis, Bristol, Conn.
Stoner, Seth H., Bristol, Conn.
Törnebohm, Hilding, Goteborg, Sweden
Westerlund, Geo. Erhard, Brooklyn, N. Y.
Williams, D. W., Cleveland, Ohio

CHANGE OF GRADING

Transfers from Junior
Greenleaf, L. B., Elkhart, Ind.
Mathews, W. L., Kansas City, Mo.
Peterson, Wm. R., Chicago, Ill.
Rosenthal, Joseph A., Newark, N. J.
Sorenson, Alfred E., Princeton, N. J.
Stetson, Ralph W., Meriden, Conn.

Transfers from Member
Cardullo, Forrest E., Cincinnati, Ohio
Dudley, Wm. Lyle, Seattle, Wash.

A.S.M.E. Transactions for January, 1937

THE January, 1937, issue of the Transactions of the A.S.M.E., contains the following papers:

Piston-Ring Friction in High-Speed Engines (AER-59-1), by Louis Illmer
Design and Operating Problems With Gas- and Oil-Fired Boilers for Stand-By Steam-Electric Stations (FSP-59-1), by V. F. Estcourt
Development of a Fuel-Injection Spark-Ignition Oil Engine (OGP-59-1), by Nicholas Fodor
A Review of Existing Psychrometric Data in Relation to Practical Engineering Problems (PRO-59-1), by W. H. Carrier and C. O. Mackey
The Contact-Mixture Analogy Applied to Heat Transfer With Mixtures of Air and Water Vapor (PRO-59-2), by W. H. Carrier
The Contributions of the U. S. Bureau of Mines to Helium Production (PRO-59-3), by C. W. Seibel
Modified I.S.A. Orifice With Free Discharge (RP-59-1), by M. P. O'Brien and R. G. Folsom